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ORIGINAL ARTICLES.

The Cretaceous Shales of Jamaica.

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(Concluded from p. 42.)

Lyria spp. (Pl. III, Figs. 16, 17, and 18.)

A well preserved specimen 46 mm. long and 22·5 mm. wide (Fig. 17) was found by Mr. R. Cory near Catadupa. The body whorl is contracted below the suture and has ten varices which die away at the anterior contraction and are slightly acute at the shoulder; the anterior part of the shell has five wavy spiral ridges. A smaller and more delicate but poorly preserved form (Fig. 18), with similar but more anteriorly produced varices, occurs just above the *Barrettia* limestone at St. Ann's Great River and resembles specimens of *L. crassicostata* Stol. from Assam figured by Spengler (*Pal. Ind.*, N. Series, vol. viii, mem. i, 1923, pl. iii, figs. 34*a* and *b*). Another species of *Lyria* or *Volutilites* (Fig. 16) with elongated spire has about 7 coarse uneven varices on the body whorl and occurs as badly preserved casts in the Providence shales. It attains a length of 47 mm.

Volutilites sp. (Pl. IV, Fig. 30.)

Shell of 7 or 8 whorls, the body whorl rather longer than the spire, the sutures sunken, the surface decorated with varices numbering about thirteen on the body whorl, crossed by numerous rather acute coarse spiral ridges. It is 21 mm. high and 10 mm. wide and occurred about 800 feet below the *Barrettia* limestone at St. Ann's Great River.

Fusus sp. (Pl. IV, Fig. 16.)

Shell of about four rounded whorls enlarging rapidly, the sutures well sunken. The body whorl is inflated but contracts rapidly anteriorly and has about eleven sharp longitudinal rather sinuous ribs which extend from the suture to the anterior contraction and are rather acute at the shoulder. The anterior contracted part bears about 10 fine spiral ridges. Length 17 mm., width 11 mm. Two imperfect specimens from the Providence shales.

Cucullaea catadupensis sp. nov. (Pl. II, Figs. 4 and 5.)

Description.—Shell thin, hinge line rather short, the beaks situated in front of the median line, close together and rather posteriorly directed. The area is narrow and inconspicuous, the anterior margin rounded, the lower nearly straight, the posterior margin rounded and expanded upwards. The ridge which passes from the hinder part of the beak to the lower posterior margin is very prominent and divides the surface into a gently rounded, medially slightly concave, anterior part and a broad gently concave posterior part. The anterior portion is decorated especially near the anterior and lower margins with a delicate reticulation, but near the beak of the right valve there are several faint radial ribs. The posterior surface bears fine concentric growth lines but the reticulation is very faint and the right valve has a faint radial decoration near the beak.

Dimensions.—The specimen (Fig. 4) is 46 mm. long, 36 mm. high, and 35 mm. in diameter. The cast of another specimen is 78 mm. long and 60 mm. high.

Locality.—The railway line between Cambridge and Catadupa about 30 feet below the Rudist limestone.

Remarks.—I cannot trace any *Cucullaea* or *Idonearca* as the American forms seem to be named, very similar to this species with its distinctly backwardly turned beaks. Professor Douvillé was uncertain of the genus of a specimen, the only one with the shell, that I showed him and suggested that it might belong to some form with a nacreous test, but I have since cleaned part of the hinge line which shows the dentition of this genus. H and A. Adams state that *Cucullaea* is equivalve, but in two recent species in my collection the right valve is appreciably smaller and its margin fits into that of the left valve. Some of the present fossils show this feature and also show a radial decoration near the beak of the right valve which is wanting on the left.

Barbatia sp. (Pl. IV, Fig. 31.)

A right valve from Providence is 22 mm. long and 14·5 mm. high; the beak is large and broad. The surface bears numerous fine slightly sinuous radial striae, which are very fine on the anterior and median part but become gradually coarser and wider apart on the raised posterior surface and still wider apart but weaker on the posterior slope. On the anterior part of the shell the striae are crossed by growth lines forming a very fine reticulation.

Septifer acutus sp. nov. (Pl. III, Fig. 9.)

Description.—Shell arched, the beaks pointed, hinder area rather wide, the hinder and lower margins well rounded, the anterior margin below the beaks concave but becoming nearly straight. The ridge is very sharp and angular, the anterior surface of the shell strongly concave. The ribs near the anterior margin are almost straight, the hinder ones tend to divide up and diverge towards the posterior and lower margin. Length 48 mm., width 42 mm., diameter of valves 20 mm.

Locality.—Providence shales and several places along the Cambridge to Catadupa railway cutting below the Rudist limestone.

Remarks.—*S. jordani* Quaas from the highest Cretaceous beds of the Libyan desert (*Palaeontogr.*, Bd. xxx, Abt. ii, Lief iv, 1902, p. 192, pl. xxii, figs. 12 and 13) is a shell similarly ornamented but smaller and broader and with a nearly straight anterior margin.

Modiolaria catadupensis sp. nov. (Pl. IV, Fig. 27.)

Description.—Shell small, elongate oval, the beaks anterior low and rounded. In front of and below the beak are a number of fine curved radial ridges which weaken posteriorly, the growth lines cross these and produce a delicate reticulation. The middle part of the shell surface bears only fine but rather irregular and discontinuous growth lines. A wide groove passes from behind the beak to the lower margin, behind which the shell surface rises to form a rounded raised posterior portion which occupies rather more than a third of the surface. This portion bears numerous fine radial divaricating ridges which rather widen out posteriorly, and are crossed by growth lines giving a faint reticulation. Length 17 mm., height 8·5 mm., diameter of valves 7 mm.

Locality.—Common in shales below the Rudist limestone between Cambridge and Catadupa.

Modiolaria sp. (Pl. IV, Fig. 28.)

Shell elongate oval; a broad groove passes from behind the beaks to rather behind the middle of the lower margin. The anterior end in front of the beaks bears fine concentric growth lines, on the median part these become faint and irregular and the raised posterior part has rather distantly spaced but regular and somewhat foliaceous growth lines but no radial ridges. Length 24 mm., height 12 mm. In shales below the Rudist limestones between Cambridge and Catadupa.

Avicula sp. (Pl. IV, Figs. 18 and 19.)

A small *Pteria* or *Avicula*-like shell is rather common in the Providence shales. The left valve occurs up to 11 mm. in length and 6 mm. in width; the beak is small and scarcely differentiated from the rounded surface, the lower posterior margin tends to be prolonged and expanded, the front and lower margins are gently curved, the posterior wing is rather broadly angular, the anterior wing very small. The surface is smooth except for growth interruptions towards the margin.

Inoceramus cf. *balticus* Böhm. (Pl. I, Fig. 6.)

An *Inoceramus* was collected and kindly placed in my hands by Messrs. J. V. Harrison and P. T. Cox in shales estimated to be about 1,000 feet below the Rudist limestone at St. Ann's Great River during their investigation into the oil possibilities of the locality. It seems to be one of the lowest Cretaceous fossils found in Jamaica.

Both valves are preserved slightly displaced, in a calcareous glauconitic concretion, they are nearly equal but the right is rather more arched and inflated than the left. The beak is small and anteriorly situated, but not terminal, and projects very little above the hinge line, the margin behind the beak is long and straight, the anterior and lower margin forms a regular almost semi-circular sweep. On the right valve the lower margin towards the base is turned down or geniculated at about a right angle, but in the left one this feature is less pronounced. The left valve has about 18 or 19 strong and regular, but rather unevenly spaced ridges, some of which merge into one another anteriorly, with broad concave interspaces. The right valve seems to have the same number of ribs as the left but they appear rather coarser especially towards the lower margin. The length is 83 mm., height 75 mm., and diameter of the valves about 51 mm.

This specimen is very near if not identical with *I. balticus* Böhm[1] the type of which comes from the Santonian, or Middle Senonian, lower Quadraten beds of Dülmen, Westphalia. It also resembles very closely examples of *I. cripsi* Zittel from Muthmannsdorf in the Gosau district (Zittel, *Bivalven der Gosaugebilde*, 1863, pl. xiv, fig. 2).

A specimen of *I. balticus* from the Senonian of Warbarrow Bay, Dorset, in the British Museum, No. L. 22177, figured by H. Woods (*Mon. Pal. Soc.*, 1912, p. 294, text-figure 51) comes very near in shape and size but has fewer and more widely spaced ribs.

I. balticus is a high Cretaceous form and occurs at Brighton in the zone of *Marsupites testudinarius* and in the zone of *Actinocamax quadratus* and *Belemnitella mucronata* in Hampshire, the Isle of Wight, Norwich, etc. Mr. H. Woods, F.R.S., in his fascinating study of the *Inocerami* which proves them to be excellent time indicators in the Cretaceous period says that *I. balticus* is closely allied to *I. inconstans* Woods from which it has probably been derived, but differs in its longer hinge and longer shell with the umbones not quite terminal.

Specimens of *I. cripsianus* Mantell figured by Stoliczka (*Cretaceous Rocks of S. India, Pelecypoda*, pl. xxvii, figs. 1–3) from the Arrialoor group of beds are also very like the Jamaican form.

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[1] *Abhand. K. Preuss. Geol. Landesanstalt*, 1909, Heft 59, pl. xii, fig. 1. A plaster cast of the original specimen is preserved in the British Museum, Nat. History.

The shape and ribbing also resembles that of figures of *I. sagensis* Owen from the Lower Marl beds at Holmdel, New Jersey, figured by Whitfield (" Brach. and Lamellibr. of the Raritan Clays and Greensand Marls of New Jersey ", *U.S. Geol. Survey*, 1885, vol. ix, pl. xiv, fig. 15), but the beak in the New Jersey shell seems broader.

It is difficult definitely to refer the Jamaican fossil to any species but it certainly comes very close to the European *I. balticus* and may be as low as Middle Senonian in age.

Exogyra cf. *overwegi* Buch.

A specimen 31 mm. high and of the same width was found by Mr. R. Cory at Catadupa, but is much encrusted with hard matrix. The smooth inrolled right valve and the flatter left valve with foliated growth lines strongly resemble figures by A. Quaas of this species which marks the Campanian and Maestrichtian in Libya and North Africa (*Palaeontogr.*, Bd. xxx, Abt. ii, Lief iv, 1902, pl. xxii, figs. 4–9).

Gryphaea cf. *hypoptera* Wanner. (Pl. IV, Fig. 26.)

A small arched valve 16 mm. wide from the Providence shales apparently belongs to this species (*Palaeontogr.*, Bd. xxx, Abt. ii, Lief iii, 1902, pl. xvii, figs. 13 and 14). It marks the Campanian in the Farafrah Oasis in Egypt. It comes very near to the well-known *G. vesicularis* Lam.

Ostrea cf. *conica* Sow. (Pl. III, Fig. 11.)

A right valve 35 mm. long from the shales along the Cambridge-Catadupa railway line recalls this species, the growth lines are numerous close-set and foliaceous.

Ostrea sp.

A right valve 41 mm. long, found about 800 feet below the *Barrettia* limestone at St. Ann's Great River, has a high conical area and a very irregular attachment surface with fine wavy foliaceous growth lines. It recalls some figures of *O. delettrei* Coq. from Egypt.

Trigonia sp. (Pl. IV, Fig. 7.)

Some poorly preserved casts of valves of a *Trigonia* with anterior erect and tapering beak occur in the Providence shales. They have twelve or thirteen prominent sinuous ribs which become closer together posteriorly, and the concave hinder areal region is decorated with close-set V-shaped costae. The ribbing on the main part of the shell resembles that on a figure of *T. mortoni* Whitfield from the Lower Greensand marls of Holmdel, New Jersey (" Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey ", *U.S. Geol Survey*, vol. ix, 1885, pl. xiv, fig. 6), but that species shows gently curved instead of V-shaped costae on the hinder area. The largest Jamaican specimen is 67 mm. long and 65 mm. high. A similar *Trigonia* occurred also in the Rudist limestone at Mooretown.

Trigonia cf. *cerulea* Whitfield. (Pl. IV, Fig. 8.)

A small broken *Trigonia* from the Providence shales has eight or nine sharp sinuous ridges with wide round-bottomed sulci between but they do not close together posteriorly; the rather concave surface behind the beak bears fine regular V-shaped costae which diverge from an almost median furrow. Length 21 mm., height about 16 mm., diameter of valves 12 mm. The ribbing resembles that on *T. eufaulensis* Gabb from New Jersey as figured by Whitfield on pl. xiv just referred to, figs. 1–3. It also resembles rather closely the immature part of a *Trigonia* I have labelled " *T. cerulia* Whitfield, Cretaceous, Texas ".

Trigonia emoryoides sp. nov. (Pl. I, Figs. 1, 2, and 3.)

Description.—Shell of moderate size, the valves well inflated medially and anteriorly; beaks prominent tapering gradually, anteriorly situated curved slightly backwards. The anterior margin is gently curved, the lower anterior and lower margins rounded, the lower posterior margin bluntly angular, the upper posterior margin broadly angular. The main surface of the shell is well rounded and bears in most specimens about 24 oblique rather sinuous ridges which gradually increase in size and width from the umbones. The summit of each ridge is cut up into a number of sharp oblique nodes and the grooves between the ridges increase in width and depth towards the lower anterior portion. The posterior surface is broad and rather concave and bears a number of raised ridges, the continuation of those on the anterior surface, but they are less prominent and closer set and are cut up into smaller but more elongate scabrous nodes. A shallow furrow passes down about the middle of the posterior area. The number of the ridges differs on individual specimens, the species being rather variable in shape and decoration.

Dimensions.—The largest specimen is 42 mm. long, 42 mm. high, and 28 mm. across the valves.

Locality.—Specimen Fig. 1 is from shales about 40 feet below the Rudist limestone on the Cambridge-Catadupa railway cutting. Fig. 2 is from the same locality but has a rather more prominent beak and fewer ribs. Fig. 3 was found by Mr. R. Cory near Catadupa and is a form more or less intermediate between the other two.

Remarks.—This scabriform *Trigonia* resembles rather closely figures of *T. emoryi* Conrad from Mexico (E. Böse, *Boletin del Instituto Geol. de Mexico*, No. 25, 1910, p. 121, pl. xxiv, figs. 1–5, pl. xxv, figs. 1, 3, 5, pl. xxvi, fig. 1) which occurs in

Cenomanian beds with *Schloenbachia trinodosa* at Cerro de Muleros but the Jamaican shell is shorter and broader and less prolonged posteriorly and seems to have a more tapering and elevated beak and more numerous and less sinuous costae. The ribbing on the Jamaican shell also recalls very strongly that on a specimen of *T. mooreana* Gabb from the Vraconian of Cerro de las conchas, Sonora, Mexico, on plate xxv mentioned above (Figs. 2 and 9). *Trigonia crenulifera* Lycett[1] is a form which according to Mr. H. Woods, F.R.S., is closely allied to *T. crenulata* Lam., and Böse compares the Mexican specimens of *T. emoryi* with *T. crenulifera.* The latter species occurs in hard rock of the Chloritic Marls between Beer Head and Sidmouth and other localities in England. The type specimen is preserved in the Geological Survey Museum in London, but the Jamaican form has a much straighter anterior margin, less posteriorly directed beaks, a broader lower posterior truncation, a less concave margin and area behind the beaks and more strongly nodose ribs which are finer and smaller on the umbones. *Trigoniae* are long lived forms of little zonal value and the Jamaican form seems to be a late relative of one or other of the Mexican species described by Böse.

Camptonectes cf. *curvatus* Gein. (Pl. III, Figs. 7 and 8.)

This species or one very near it occurs in shales at Providence and along the Cambridge-Catadupa railway line. The outline of the valves seems to vary somewhat, being more produced anteriorly in some examples than in others. A right valve is 20 mm. high and 19 mm. wide and the posterior auricle is 4 mm. long and is well excavated below, and the surface shows the characteristic divaricate ribbing. The Jamaican specimens compare well with figures of examples from Zululand and from the Arrialoor beds of South India. Mr. H. Woods figures specimens from the Chloritic Marl of Eastbourne in England.

Pecten cf. *septemplicatus* Nilsson. (Pl. II, Fig. 3.)

Description.—A left valve is 22 mm. high and 21 mm. wide, the anterior auricle is missing but the posterior one is 7 mm. long and is well excavated below. There are ten prominent rounded radiating ribs becoming nodose near the margin which is abruptly geniculated. The whole surface including the ribs and furrows bears small radiating ridges, three or four of which occur on each of the main ribs. Growth lines are faint and sharp.

Locality.—Providence shales. Bed J in section Fig. 2.

Remarks.—Zittel figures specimens from Gosau (*Bivalven der Gosaugebilde*, 1864, p. 37, pl. xviii, figs. 3*a*–*c*). A rather similar form figured by Spengler, *Pecten assamensis*, but apparently with flatter ribs, occurs in the Upper Cretaceous of Assam (*Pal. Indica*, N. Series, 1923, vol. viii, mem. i, p. 16, pl. ii, figs. 9 and 10).

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[1] *Mon. Brit. Fossil Trigoniae*, 1872–9, p. 189, pl. xl, figs. 1*a*–*b*, 7, 9, and 9*a*.

Amusium (?) cf. *membranaceum* Nilsson. (Pl. IV, Fig. 23.)

A left valve of an extremely thin shelled form, 8 mm. high and the same wide, comes from shales above the *Barrettia* limestone at St. Ann's Great River. The anterior auricle scarcely projects beyond the margin of the shell, the posterior one is almost rectangular. The surface is smooth except for occasional faint growth furrows.

It may be identical with the above fossil that occurs in upper and middle Cretaceous beds in Sweden, Hanover, Maestricht, Gosau, etc. Stoliczka figures specimens from the Arrialoor beds of South India (*Pal. Ind.*, vol. iii, 1871, pl. xxxii, fig. 5; pl. xli, figs. 7–8).

Neithea quinquecostata J. Sow. (Pl. I, Fig. 8.)

This fossil showing a certain amount of variation, is common in the Providence shales and along the railway cutting between Cambridge and Catadupa. A form with the left valve narrowing rapidly and strongly arched is most common.

Neithea quadricostata J. Sow.

A specimen from calcareous shales among the Rudist limestone sequence at Logie Green has traces of red colour marking and resembles figures of examples from the Maestrichtian of the Mari Hills in Baluchistan and from Zululand. Similar specimens occur in the dark shales above the *Barrettia* limestone at St. Ann's Great River.

Neithea sp. (Pl. IV, Fig. 25.)

Shell small, the left valve is elongate, tapering, and moderately arched; the auricles are small. The surface has about fifteen fine rounded radial ribs of which three are more prominent than the others. Height 10·5 mm., width 6 mm., depth of valve 4 mm.

From shales above the *Barrettia* limestone at St. Ann's Great River.

Plicatula sp. (Pl. IV, Fig. 37.)

An unattached valve is 19 mm. high and 17 mm. wide. It is gently convex and has coarse foliaceous growth ridges and the surface bears numerous radial ribs, some of which develop into tubular spines up to 3 mm. in length, which stand upright from the surface. It occurs in shales above the *Barrettia* limestone at St. Ann's Great River and is not unlike some figures of *P. andersoni* R. B. Newton from Zululand (*Trans. Roy. Soc. S. Africa*, ol. i, pt. i, 1909, pl. ii, figs. 15–17).

Plicatula cf. *urticosa* Morton.

A shell from above the *Barrettia* limestone at St. Ann's Great River is attached by the greater part of the surface of the right valve. The upper valve when young has very fine radial riblets, the adult part bears coarse irregular, angular, occasionally bifurcating plications, some of which are slightly spinous. It is 19 mm. high and wide and recalls figures of this species from the lower green marls of New Jersey (R. P. Whitfield, *U.S. Geol. Survey*, vol. ix, 1885, p. 61, pl. ix, figs. 1 and 2).

Pholadomya jamaicensis sp. nov. (Pl. III, Figs. 4, 5, and 6.)

Description.—Shell of moderate size, the anterior and middle parts well inflated, the beaks rather anterior, small and tapering rapidly, rather forwardly directed and inrolled. The anterior and lower margins well rounded, the posterior moderately prolonged and rounded. In front of the beaks a concave lunular depression occupies about half the length of the anterior side. The anterior third part of the surface is decorated with about fourteen, regular rounded concentric ridges with shallow sulci between, which start from the margin of the lunule and follow the outline of the shell. Behind these are about fourteen radial ridges which start from the hinder part of the beak and diverge downwards and backwards and have shallow gradually widening sulci between them. The anterior ridges are small, weak and close set but they gradually increase in strength and diverge posteriorly. They cover rather over a third of the surface and near the beak are crossed by the anterior growth ridges giving a reticulate ornamentation. The posterior part of the shell is smooth and concave or it may have one or two broad and wide radial ribs. A large specimen is about 44 mm. long, 33 mm. high, and 26 mm. in diameter across the valves.

Locality.—It is common in the shales at and near Providence but scarce along the Cambridge-Catadupa railway cutting.

Remarks.—I cannot trace any *Pholadomya* very near to this one except perhaps *P. vignesi* Lartet from the Cenomanian and Turonian of Syria, Socotra, Zululand, etc. Specimens from Zululand figured by R. B. Newton (*Trans. Roy. Soc. S. Africa*, vol. i, part i, 1909, pl. vi, figs. 3–6) show a shorter and higher shell with radiating ribs extending nearly to the anterior margin.

Pholadomya tigroides sp. nov. (Pl. I, Fig. 7.)

Description.—A single specimen from the Providence shales with both valves in position but the posterior end missing has broad rather anteriorly situated beaks, the anterior margin is well rounded the lower margin almost straight. About 23 sharp radial ribs with broad grooves between them diverge from the beak. They are irregularly spaced, but are widest apart on the anterior and medial part and are smaller and closer together posteriorly, while near the upper hinder margin they widen out and weaken and disappear. The specimen has been about 73 mm. long, 44 mm. high, and 40 mm. across the valves.

Remarks.—It recalls *P. tigris* Noetling from the Maestrichtian of the Mari Hills in Baluchistan (*Pal. Indica*, ser. XVI, vol. i, pt. iii, 1897, p. 52, pl. xiii, figs. 6 and 6*a*) but the Jamaican shell has a less abrupt anterior truncation. The acute and rather wavy ribs resemble those on *P. occidentalis* Morton from the lower green marls of New Jersey figured by Whitfield (*U.S. Geol. Survey*, Mon. ix, 1885, pl. xxiv, figs. 1–3) but the outline of the lower margin is straighter on the Jamaican form.

Thracia (?) sp. (Pl. II, Fig. 8.)

A right valve of a thin shelled species from Providence may belong to this or some allied genus such as *Periploma* or *Liopistha*. The outline is oval, the beak tapering and directed forwards and the lunular margin below is strongly excavated. The surface is smooth except for broad irregular growth furrows towards the lower margin. Length 42 mm., height 35 mm.

Pleuromya sp. (Pl. III, Fig. 14.)

A very thin shelled bivalve possibly with a slight gape in front and behind and broad forwardly directed beaks may belong to this genus. The valves are well inflated and bear fine concentric growth lines but the shell is easily weathered away. It is 36 mm. long, 31 mm. high, and 24·5 mm. in diameter and comes from shales along the Cambridge-Catadupa railway cutting.

Roudaireia jamaicensis sp. nov. (Pl. II, Figs. 1 and 2.)

Description.—Shell with the beaks anterior, nearly terminal in some specimens, almost touching one another. The posterior margin is gently curved, the lower margin slightly curved, the lower anterior margin rounded, the area below the beaks broadly sunken. The ridge which passes from behind the beaks to the lower posterior margin is acute at first, but becomes lower and blunter on the adult shell and continues to the hinder margin which becomes rather prolonged and angular. The surface of the young shell in front of the ridge has well marked concentric ridges and sulci which gradually decrease in strength; the more adult shell has a nearly smooth surface except for fine growth lines and occasional coarse growth interruptions, but near the lower margin the growth lines become coarser and closer set. The surface behind the ridge is concavo-convex and bears coarse close-set growth lines. The hinge teeth have not been seen.

Dimensions.—The largest example is 81 mm. long, 74 mm. high, and 59 mm. across the valves. A small specimen is 37 mm. long and 31 mm. high.

Locality.—The small and more elegantly shaped specimen was collected by Mr. R. Cory near Catadupa. I found three or four larger and somewhat variable and irregularly grown examples in shales about 40 feet below the Rudist limestone along the Cambridge-Catadupa railway line.

Remarks.—This species approaches *R. auressensis* Coquand of the Campanian and Maestrichtian of Egypt and North Africa, but the Jamaican form has a more tapering beak and a more prolonged and angulated lower posterior margin and, except in the very young stage, a smoother and less sulcated surface. R. Fourtau[1] quotes *R. auressensis* as synonymous with *R. drui* Mun. Chalm. but figures of the latter species by A. Quaas[2] from the *Overwegi* beds of the Dachel and Chargeh Oases show a shell with an outline resembling the Jamaican species but with a more strongly ribbed surface.

Veniella forbesiana Stoliczka is a fossil that is found in the Trinchinopoly group of India and also in the Cretaceous beds of Zululand.[3] It seems however to be a shell with a much broader beak and more rounded outline than the North African or Jamaican forms.

Veniella sp. (Pl. IV, Figs. 1 and 2.)

Two casts, one with both valves and the other a single right valve, seem referable to this genus or to *Roudaireia*. The shell seems thin, the beaks pointed and anterior and the margin concave below them. The lower margin is gently curved, the lower hinder margin rather produced, the upper hinder margin broadly angulate. The surface has about three broad concentric ridges and there are traces of fine growth lines. Length 18 mm., height 17 mm., diameter of both valves 19 mm.

From the Providence shales. No trace of the hinge line and little of the shell is seen, but these specimens seem to be related to *V. elevata* Conrad and *V. conradi* Morton from the Cretaceous of New Jersey (*U.S. Geol. Survey*, vol. ix, 1885, pp. 144 and 148, pl. xix, figs. 6–10).

Cardita sp. (Pl. III, Fig. 10.)

Shell outline sub-quadrate, the beak anterior, the lower margin very gently curved, the lower posterior margin rather produced. The surface has about twenty-two straight or gently curved radial ridges which bear rather coarse growth foliations becoming spinous near the anterior and upper posterior margins. Near the median surface the spines and foliations are eroded and the ridges become fine and sharp. Height 10·5 mm., length 14·5 mm., diameter of valves 8·5 mm. Two specimens found in the shales between Cambridge and Catadupa.

Antillocaprina (?) sp. (Pl II, Fig. 10; Pl. IV, Fig. 6.)

I collected several more or less crushed specimens of a Rudist in shales about 30 feet below the limestone along the Cambridge-

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[1] Terrain's Crétacés, 2me Partie, *Geol. Survey of Egypt*, Pal. Series, No. 3, 1917, p. 63, pl. iii, figs. 2 and 3.

[2] *Palaeontographica*, Bd. xxx, Abt. ii, Lief iv, 1902, pl. xxiv, figs. 20–22.

[3] R. B. Newton, *Trans. Roy. Soc. South Africa*, vol. i, pt. i, 1909, pp. 67, pl. vii, figs. 1–4.

Catadupa railway line. It seems to have been a free or very lightly attached form, nearly equivalve but having the right valve rather larger and more conical than the left; the latter being capuliform, arched and with the spire anteriorly directed. The outer layer of the shell is very thin and apparently smooth except for fine rather widely spaced longitudinal ridges, crossed towards the junction of the valves by fine irregularly spaced growth ridges. The middle layer seems to be composed of fine longitudinal tubules as in the genus that I called *Antillocaprina* (Geol. Mag., Vol. LXI, Sept., 1924, p. 407) which includes the *Caprinella occidentalis* of Whitfield. Crushing renders it impossible to ascertain the nature of the inner layer or of the hinge teeth. One specimen has the right valve 38 mm. long and the left valve 31 mm. high, another one has the right or attached valve nearly as strongly arched as the left, both together being 68 mm. I have not seen this form in any of the limestones in the Cretaceous beds of Jamaica.

Cardium cf. *gosaviense* Zittel. (Pl. I, Fig. 9.)

Shell thin, elongate, narrow; beaks tapering, nearly median. The ornamentation is obliterated near the umbones but elsewhere consists of about twenty-five fine radial ridges the edges of which are cut up into rows of small spines. Length 23 mm., width 18 mm., diameter across the valves 16 mm. In shales along the Cambridge-Catadupa railway line.

Cardium (*Fragum* ?) sp. (Pl. IV, Fig. 13.)

Shell rather thick: beaks small and inconspicuous, rather in front of the median line, the anterior and lower outline almost semicircular, the posterior slope rather abrupt. The surface has numerous ribs that radiate from below the umbones and bear small foliaceous spines, but become smaller on the posterior slope. Height 17·5 mm., width 15 mm. From Catadupa, one specimen found by Mr. R. Cory, others found by me in a piece of shaly limestone along the railway cutting that may have been above the Rudist limestones.

Laevicardium (?) sp. (Pl. II, Fig. 9.)

Shell large, thin, inflated; the beaks prominent and tapering. The anterior auricle is rather produced and rounded, the posterior one reduced, the anterior and lower margins rounded. The young shell is marked with very fine close set radial ribs, the later shell seems to have been smooth but is much encrusted with *Anomiae* and other growths. Height 70 mm., width 57 mm., diameter across both valves 57 mm. From shales below the Rudist limestone on the Cambridge-Catadupa railway.

Laevicardium sp. (Pl. III, Figs. 12 and 13.)

Shell small, thin; the beaks nearly median, forwardly rolled with lunular depression below, the auricles scarcely developed, the margins gently rounded. Surface smooth, but some specimens show very faint fine radial ribs especially near the sides and margin. Height 22 mm., width 18 mm., diameter of valves 15 mm. From the shales at Providence and between Cambridge and Catadupa.

Cardium spp.

Casts, some of them crushed, of a thin-shelled form have arched and inflated valves and rather produced posterior auricles. The surface bears numerous fine radial ribs which become nodose near the margins. Height 49 mm., width 49 mm., diameter 41 mm. From the Cambridge-Catadupa railway cuttings. They resemble casts of *Cardium* spp. from the Maestrichtian of Egypt figured by R. Fourtau.

Cardium sp.

An arched laterally compressed form with tapering beak and numerous fine and even radial ribs, 14 mm. high, 12 mm. wide, and 9 mm. deep from the Providence shales resembles figures of *C.* cf. *becksii* J. Müll. from the highest Cretaceous of Egypt (*Palaeontogr.*, Bd. xxx, Abt. ii, Lief iv, 1902, pl. xxiv, figs. 16 and 17).

Cytherea catadupensis sp. nov. (Pl. II, Fig. 7.)

Description.—Shell thick, outline elliptical, the beak low and broad merged in the general outline and curvature. The lunule is well sunken but small and not bounded by a ridge, the escutcheon is broad and sunken. The surface is well arched and rounded and is smooth except for regular concentric rather coarse growth lines. Height 42 mm., length 48 mm., depth of each valve 15 mm.

Locality.—The railway line between Cambridge and Catadupa in shales about 40 feet below the Rudist limestone.

Remarks.—A specimen with both valves open, and a single left valve seem to belong to this genus though the hinge teeth are not clearly visible. The shell is more arched and elliptical and the beak is broader and less prominent than in *C. plana* Sow. of the Upper Greensand. A rather similar shell, *C. rohlfsi* Quaas, occurs in the Campanian beds of Egypt (*Palaeontogr.*, Bd. xxx, Abt. ii, Lief iv, 1902, p. 224, pl. xxiv, figs. 24–5; pl. xxv, figs. 1–4) but the Jamaican form differs in having a more rounded beak and a much smaller lunular area.

Cytherea spp. (Pl. II, Fig. 6.)

At least two species of poorly preserved *Cytherea*-like shells occur in shales above the *Barrettia* limestone at St. Ann's Great

River. One is figured and another 31 mm. long and 26 mm. high recalls in shape *C. plana* Sow.

Legumen cf. *appressum* Conrad. (Pl. III, Figs. 2 and 3.)

Valves very slightly convex with flat depressed beaks situated in front of the anterior third of the shell which narrows anteriorly and widens somewhat posteriorly. Both ends are gently rounded and the surface is marked with fine regular concentric ridges which become faint towards the beaks. A specimen with both valves lying on the rock (Fig. 2) comes from the Providence shales, each valve is 40 mm. long and 15·5 mm. high near the posterior end with a ligament 8·5 mm. long. Another example (Fig. 3) from the Cambridge-Catadupa railway cutting has valves 41 mm. long and about 22 mm. high but the beak is rather more raised above the hinge margin.

Both specimens agree fairly well with figures of this species from the Lower Marls at Haddonfield, New Jersey (Whitfield, *U.S. Geol. Survey*, 1885, vol. ix, pl. xxv, figs. 6–8).

Legumen (?) sp. (Pl. III, Fig. 1.)

A shell with flattened valves, broad and low beaks, and a gently rounded hinder margin occurs in shales on the Cambridge-Catadupa railway line and at Providence and may belong to this genus. The surface bears fine regular concentric growth lines which weaken or have been eroded near the beaks. Length 35 mm., height 24 mm., diameter of valves 8 mm.

Tellina (?) sp. (Pl. I, Fig. 5.)

Two right valves, one from Providence and the other from the Catadupa railway cutting, of a thin shelled form with fine concentric growth lines seem to belong to this or some allied genus. A valve is 33 mm. long and 23 mm. high. Features are obscure except that a broad swelling passes from in front of the beak to the lower anterior margin.

Corbula sp. (Pl. IV, Figs. 21, 22, and 22*a*.)

Description.—The right valve is well inflated anteriorly; the beak anterior, nearly terminal and prominent; the anterior side is abruptly truncated becoming concave. The anterior margin is straight, the lower margin strongly geniculated, its outline gently rounded, the hinder margin broadly rostrate, its upper posterior edge turned upwards. A blunt curved inconspicuous ridge passes from behind the beak to the lower posterior margin. In front of this the ornamentation consists of thirty-five or more regular rounded concentric ribs which lessen in strength towards the lower margin. Behind the ridge the ribs still continue but become irregular and wavy. The left valve has a rather pointed and elevated beak and the surface bears numerous fine and close-set rounded growth ridges. A right valve is 9 mm. long, 7 mm. high, and 4 mm. deep.

Locality.—In shales about 900 feet below the *Barrettia* limestone at St. Ann's Great River.

Remarks.—This shell rather resembles *C. parsura* Stoliczka ("Cret. Fauna of S. India", *Pal. Ind.*, vol. iii, 1871, p. 44, pl. xvi, figs. 3–4).

Terebratulina (?) sp. (Pl. III, Fig. 15.)

Among the very few Brachiopods found in the Cretaceous of Jamaica is a form from the Providence shales apparently referable to this genus. The ventral beak tapers and is arched over the dorsal valve. It is 29 mm. long, 22 mm. wide, and 16 mm. across the valves and bears traces of numerous low flattened radial ribs with sharply cut grooves between them.

CORRELATION.

The fossils herein described fall into three categories (*a*) those which seem to be new species, (*b*) well-known but long-lived forms such as the Pectinidae, *Trigonia*, *Cucullaea*, etc., which are of little use in fixing horizons and thirdly (*c*) those whose zonal evolution has been traced in different areas such as the *Inocerami*, or forms which appear on a high Cretaceous horizon in other countries such as the genus *Roudaireia*. These last together with the Cephalopoda already described by Dr. L. F. Spath point to the conclusion that the Jamaican fossiliferous Cretaceous beds belong to a very high horizon, while the remainder of the fauna does not seem to yield any evidence that would seriously invalidate this supposition.

The beds 1,000 feet or so below the Rudist limestone at St. Ann's Great River which yield *Inoceramus* cf. *balticus* and *Turritella cardenasensis* may be as low as Middle Senonian but the *Barrettia* and other Rudist limestones are certainly very high Senonian if not Maestrichtian. The shales above the limestone at St. Ann's Great River then are still later in age, and their fauna bears a general resemblance to that described by Wanner from the highest chalk of the Libyan desert and by A. Quaas from the *Overwegi* beds and Paper Shales of the same region.

Parapachydiscus and numerous *Baculites* which occur rather low in the sequence of shales at Providence suggest a Campanian horizon, and the same may be said of the shales beneath the Rudist limestones along the railway cutting between Cambridge and Catadupa which yield a *Roudaireia* very similar to *R. auressensis* or *R. drui* of the Campanian of Egypt and North Africa.

The Rudist limestones of Jamaica contain a fauna which seems to have practically no species in common with the Old World, a feature no doubt largely due to their isolated and reef-like conditions of growth. The shales, on the other hand, especially those below the Rudist limestones, yield a fauna of a more cosmopolitan character but with apparently as much American (Mexico and New Jersey) as Old World affinity. It is perhaps too soon as yet to generalize on West Indian palaeontology, but the fact emerges that the Eocene, including the Middle Eocene Yellow Limestone in Jamaica and to a rather less extent the higher Eocene Scotland beds of Barbados, are much more African and Old World in their fauna than is the Cretaceous. This hardly supports the westerly continental drift hypothesis unless we are permitted to suppose that the continents moved towards one another again in Eocene times (!). I recently had the privilege of examining in Havana an extensive collection of fossils and other natural history specimens gathered by Dr. Mario Sanchez Roig from various localities in Cuba. The *Barrettia* limestone is well represented in his collection, the fossils being considerably hardened and marmorized. Various small *Rudistae* similar to some of those from Jamaica also occur, but as yet no Cretaceous shaley fauna has been found. There are no specimens in his collection that might correspond with the Richmond beds (basal Eocene with derived Cretaceous fossils) or the Yellow Limestone (Lutetian) of Jamaica. The rich and conspicuous Yellow Limestone fauna should have been noticed if it occurs in Cuba. In Haiti the Plaisance Limestone contains two fossils named by Woodring and Mansfield[1] *Pseudomiltha haitensis* and *Chama engonia*. The latter may be the same as a shell from Jamaica I called *Pseudoheligmus* (?) *jamaicensis* and the Plaisance and the Yellow Limestones are taken to be equivalent. It seems possible then that in Middle Eocene times the northern limit of the Tethyan sea with its Old World fauna should be drawn between Jamaica and Cuba.

Perhaps I may be excused in again referring to a recent controversy on the age of the beds described in this paper. Professor H. L. Hawkins in his paper on the Echinoidea from Jamaica (Geol. Mag., July, 1924, p. 315) states that Dr. Woolacott had forestalled him in attributing the Jamaican Cretaceous limestones to the Turonian. In 1920 the late Dr. Woolacott visited Jamaica and brought back several Cretaceous fossils, and asked my opinion on the age of the beds; I said I thought they were the equivalent of the Gosau beds or approximately Turonian. I was unable to reach Jamaica at that time owing to shipping difficulties but I went there the following year, when as a result of examination of the fossils "in situ" I concluded that the series was considerably higher than Turonian, in fact high Senonian or Maestrichtian in age.

Can Professor Hawkins assign any reason why his Echinoid species *Goniopygus supremus*, *Botryopygus rudistarum*, and others may not have existed in the Campanian or Maestrichtian seeing that their molluscan associates generally show high Cretaceous affinities, or must their attitude remain that of the Irishman on the jury when all but he had agreed on their verdict and who is reported to have said " eleven more obstinate men I never met in my life " ?

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[1] W. P. Woodring and others, *Geology of the Republic of Haiti*, 1924, pl. x, p. 612.

Some Observations on the Geology of Viti Levu.

By C. A. MATLEY, D.Sc., F.G.S., and A. MORLEY DAVIES, D.Sc., A.R.C.S., F.G.S.

- **I. Introduction (C. A. M.).**
- **II. Field Observations (C. A. M.).**
- **III. Palaeontological Notes (A. M. D.).**
- **IV. Conclusion (C. A. M. and A. M. D.).**

I. INTRODUCTION (C. A. M.).

IN the course of a voyage across the Pacific in September, 1924, from Vancouver to New Zealand, I broke my journey at Suva for four weeks with the object of seeing something of the geology and scenery of Viti Levu. Half that time, however, was spent in a cruise to the Tonga Islands and Samoa, leaving therefore only a fortnight for Viti Levu, but His Excellency the Acting Governor, the Hon. T. E. Fell, C.M.G., gave me facilities for visiting the mountainous country of the interior which enabled much more of the island to be seen in that short time than would otherwise have been possible. To him and to other officers of the Government who assisted me in my tour I offer my best thanks. Mr. F. R. Charlton, the Acting Crown Surveyor, accompanied me on my coastwise journey and in a traverse across the island from north to south. His knowledge of the country and of the Fijian language and customs was invaluable. Major Caldwell, Mr. Reay, and Mr. Armstrong, the District Commissioners through whose areas we passed, gave us hospitality and every assistance possible, and Mr. Boyd, the Commissioner for Native Affairs, made arrangements with Fijian chiefs, in whose houses we were charmingly and hospitably entertained. When making the tour I had no intention of writing any account of it for publication, but several new facts came to light which it is desirable to place on record.

As an American geologist has since spent six months in Viti Levu, and has undertaken to present a comprehensive report on its stratigraphy and palaeontology, the present paper will be restricted to a short account of the more important results of my visit.

Viti Levu consists chiefly of volcanic rocks, mainly or entirely of Tertiary age, and of sediments derived therefrom by denudation, together with some limestones and a core of plutonic and metamorphic rocks which is considered by Wichmann, Woolnough, Foye and others to represent an ancient continental basement. Basement rocks of continental type have been discovered in the New Hebrides and in New Caledonia, but Viti Levu is even more distant than they are from the continental masses of the present day. For an account of the present state of our geological knowledge the reader is referred to the excellent summary in F. R. C. Reed's *Geology of the British Empire* (1921, pp. 433–8). A still more recent account is given by Professor R. W. Brock [1] who has revised earlier classifications of the geological sequence.

II. Field Observations (C. A. M.).

Walu Bay and Tamavua Limestone.—This limestone is well exposed close to Suva. Owing to its accessibility and its richness in fossils, this and its associated " soapstones " are the best known deposits in the island. By some geologists its age is considered to be post-Tertiary, and by others to be Miocene or Pliocene, the evidence for the greater antiquity being chiefly based on the presence of *Carcharodon* teeth. When Woolnough described it in 1903 [2] the exposure at Walu Bay was a natural cliff-section, but the rock has since been cut back to provide material for a reclamation area and the beds are now probably better exposed. In Woolnough's section the limestone (with a band of large pebbles at its base) is shown as a bed 40 feet thick intercalated in horizontal " soapstones " and with its base 136 feet above sea-level. Its thickness is, however, often less, say 20 feet, it is fractured by a number of faults of several feet throw and tilted at various angles, so that the base sometimes approaches sea-level and sometimes, as at Tamavua, is elevated as high as, or even higher than, shown by Woolnough. A sketch of the faulting, sent me by my friend, Mr. F. R. Charlton, is given above (Fig. 1). The limestone has suffered considerably from solution, its abundant corals being poorly preserved as casts and most of the mollusca being also in the condition of casts, though occasionally the shell-substance is preserved. Apart from any palæontological evidence the condition of the limestone and its fossils seems to indicate an age older than

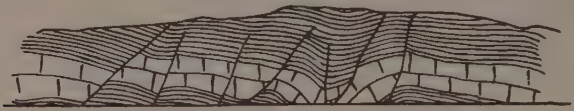

Fig. 1.—Faults in limestone at Walu Bay. (From a sketch supplied by Mr. F. R. Charlton.)

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[1] " Sketch of the Geology of Viti Levu, Great Fiji " : *Trans. Roy. Soc. Canada*, vol. xviii, 1924, pp. 63–83.

[2] " The Continental Origin of Fiji " : *Proc. Linn. Soc. N.S.W.*, 1903, pt. iii, pp. 463–4 and pl. xxiv.

Pleistocene. No complete study of the fauna has yet been made, though Mansfield has recently (since my visit) described the collection of mollusca, also one Carcharodon tooth, in the United States National Museum.[1] I was fortunate in finding at the base of the limestone a bed of large foraminifera, chiefly belonging to the genus *Cycloclypeus*, one species being about 2 inches in diameter, and these together with my collection of mollusca have been dealt with by Professor Morley Davies, whose description of them will be found in a later part of this paper. The corals have been sent, through Dr. T. Wayland Vaughan, to the United States National Museum, for study, in conjunction with other collections from this locality, by Dr. J. E. Hoffmeister.

No evidence has been found in the fossils examined to oppose the view expresed by Mansfield that "the fauna suggests a Tertiary age, probably late Miocene or early Pliocene" (op. cit., p. 94).

Kalabu Limestone.—The small village of Kalabu, well known to the inhabitants of Suva on account of its cave and subterranean stream, lies a few miles from Suva and 4½ miles in a direct line from the Walu Bay limestone. Near the village, which is built on a soft fossiliferous limestone, in appearance much like that at Walu Bay, is a cave which has been eroded along a joint plane in the limestone by a subterranean stream. The stream sinks into it at its upper end and emerges at its lower outlet where a base level of erosion has been formed by a barrier of igneous rock. Mr. Charlton and I explored the whole length of the cave, some 100 yards or more, the distance being difficult to estimate during a single traverse, made in dim torchlight partly by wading, partly by swimming. The cave is lofty, its greatest height, according to the villagers, being 15 fathoms. The limestone is quite 20 feet thick, and its lower part contains many well-rounded pebbles of igneous rocks, some of large size, the largest I measured being 16 inches in length. Many corals occur in the limestone, as at Walu Bay, but I saw fewer mollusca. Portions of it consist of large foraminifera, with an admixture of sandy igneous detritus, many of the foraminifera being about 2 inches in diameter. The limestone passes up into "soapstone" which can be seen in the roof of the cave, and its conglomeratic base rests on laminated sandy beds which are also part of the soapstone series. But the lower beds are absent at the outlet of the cave as the limestone there is seen to lie directly on basalt or andesite. The geological structure seems to be as shown in the accompanying diagram (Fig. 2), which suggests that we have here a local base to the soapstone series, and that the soapstones and limestone rest on an irregular surface of older volcanic rock against which the lower beds abut. The geology of this locality deserves fuller investigation than I had an opportunity of making during my brief visit.

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[1] *Fossils from Quarries near Suva*, etc.: Pubn. 344, Carn. Inst., Washington, 1926, pp. 85–104.

The Kalabu Limestone, in spite of its close resemblance to the Walu Bay Limestone in its lithology, its conglomeratic base, its intercalation in the soapstone series, and in the presence of large foraminifera, is evidently an older deposit. The contained foraminifera are an entirely different assemblage from those at Walu Bay and are definitely Miocene, as the chief forms are species of *Lepidocyclina*. It may be remarked that this genus has previously been found in the Fiji Group only in the distant islands of Mango (*L. sumatrensis*) and Namuka (*L.* sp. indet.).

Soapstone Series.—The beds of mudstone, marl and sandy material (known locally as "soapstones"), made chiefly of volcanic detritus, are widely distributed in Viti Levu. These water-laid deposits were shown by Woolnough to occur not only at low levels near the coast (as, for instance, around Suva) but also at high elevations (up to over 4,000 feet) in the interior. Woolnough regarded the soapstones as all belonging to a single series, but later writers (Foye, Brock) claim that the higher-level beds of Central Viti Levu form an older series separated by a period of earth-movements from the younger coastal series. The present writer has seen too little of the island to express an opinion on this important point, except to say that these writers regard the interior series as probably of Miocene age and the coastal series as "apparently post-Tertiary" (Foye) or "Pleistocene?" (Brock).

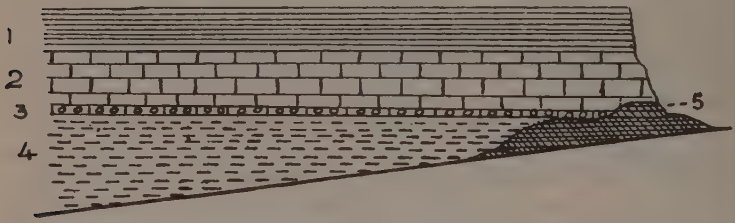

FIG. 2.—Section at Kalabu Cave: 1. Soapstone. 2. Limestone. 3. Conglomerate. 4. Laminated Sandstone. 5. Basalt or Andesite.

As fossils have not been recorded from the soapstones of the interior I may mention that I found *Globerigina* in typical soapstones on the Nadarivatu road, less than 1 mile from Nasoqo. They dipped at 35° N.E. and appeared to be overlain by a basalt flow or an agglomerate. My aneroid reading was 1,340 feet, and if it is correct—it was not corrected for sea-level and is probably too high—these fossils occur at a higher level than any yet recorded from Viti Levu. Woolnough found marine shells and a coral at 1,290 feet (aneroid) at Nadrau, and his only other high-level record is a fossiliferous marine conglomerate at Nasoqo at 800 feet. I also found well-bedded mudstones in the right bank of the Wainimala, $\frac{1}{4}$-mile above Narukuruku (between Vunuyasi and Serea) to be very fossiliferous and to contain *Globigerina*, pteropods, and other tiny mollusca, and plant fragments. They dip at a low angle (5° to 10°).

The Suva soapstones contain a remarkable echinoid, 5 or 6 inches in diameter, of which I saw three examples in the Suva Museum, and two more at the University of Sydney which I have obtained on loan through the kindness of Professor L. A. Cotton. Dr. F. A. Bather informs me that it belongs to the same genus as a form described from Barbados.[1] The Barbadian fossil is regarded as a deep-sea echinoid and the radiolarian marls in which it was found as abyssal deposits. The Suva examples, on the other hand, evidently come from the soapstones associated with the shallow-water and conglomeratic limestone of Walu Bay and are clearly not of deep-sea origin.

High-level Freshwater Fossils.—The exposures around Nasoqo are highly interesting. It was near this village that Woolnough found a high-level marine conglomerate (at 800 feet) containing pebbles of quartz-diorite from the Basal Complex. The village stands above the river Wailoa on coarse agglomerate. Above the village, on the Ngelewai road, bands of conglomerate, intercalated with red-weathering clays, occur up to a height of 300 feet above the river. Still higher the road exposes a buff or light-brown friable felspathic sandstone containing abundant casts of pelecypods and some plant-fragments including impressions of dicotyledonous leaves. The (uncorrected) aneroid reading here was 1,140 feet. Conglomerates were seen again in force about a mile or more further on, at a level 100 feet higher, and also in a good section at Tagiruku where a waterfall passes over them. Quartz-diorite pebbles from the Basal Complex were found in them here.

The presence of plant leaves in the mollusca-bearing sandstone indicates the close proximity of land, and the mollusca themselves appear to be freshwater forms belonging to the Unionidae, a family of freshwater mussels unknown in Fiji at the present day. As the occurrence of these fossils has an important bearing on the geological history of the Fiji Islands it is to be hoped that further collections will be made and the tentative conclusions arrived at by Professor Morley Davies confirmed and extended. It is unfortunate that Mr. Charlton and I were unable to spend more than a few minutes in collecting fossils from this bed, owing to the necessity of finishing our day's march on a difficult road in daylight.

Basal Complex.—I was able to see the plutonic and associated rocks of Viti Levu at only one locality, namely around Matainasau, on the Wainimala, where I also collected some river-pebbles derived from them. I saw, however, enough to be satisfied of the existence of an ancient series of rocks underlying the volcanic cover. A few of the rocks collected have been sliced, and Dr. H. H. Thomas has kindly described them for me. Among them is a pale-grey felsitic-looking rock, having somewhat the appearance of a fine-grained quartzite, iron-stained and speckled with pyrites, but not obviously sedimentary. It occurs in the Wainimala at the ford above Matainasau. Microscopic examination shows that it is a fine arkose derived from quartz-albite porphyries and granophyre. It is traversed by narrow veins of quartz and much silicified. Another rock found loose in the stream at the ford is foliated and has a pseudo-schistose structure impressed upon it by intense crushing. No traces are left of its original constituents or of its original structure, and it now consists of a mass of pale chlorite and serpentine, deeply iron-stained and traversed by veins of secondary silica. It is most probable that the rock was either a moderately basic lava or tuff, and in its present condition may be best described as a schalstein. Another loose block looks like an indurated shale. The microscope shows that practically all the original structures have been obliterated by the shearing, silicification, and chloritization that the rock has suffered, but traces of original banding and variation in composition suggest that it was originally a fine shaly mudstone or tuff with thin coarser quartzose and felspathic partings. A fourth rock is a pebble from the confluence of the Wainimala at Laselevu. It is composed of a microcrystalline aggregate of chlorite, actinolite, and iron-epidote, and thus merits the name of epidosite. It is metamorphic in character and is probably derived from an area of hornblende schists.

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[1] J. W. Gregory, "*Cystechinus crassus*, a new species from the Radiolarian Marls of Barbados and the Evidence it affords as to the Age and Origin of those Deposits": *Q.J.G.S.*, vol. xlv (1889), pp. 640–50.

The above descriptions are sufficient to prove that these old rocks have suffered intensely from earth-stresses and metamorphism. Another specimen collected close to the village of Matainasau is a dark iron-stained, fine-textured and highly vesicular spilitic lava. The rock is entirely decomposed but its volcanic structure is well preserved. It probably belongs not to the Basal Complex but to its volcanic covering.

III. PALAEONTOLOGICAL NOTES (A. M. D.).

(*a*) *Fossils from the Limestones of Walu Bay and Tamavua.*

A series of mollusca, internal casts with occasional fragments of shell attached, was collected from Walu Bay and Tamavua, and in addition foraminifera from the former locality. Some of the mollusca are identical with forms described by Mansfield (*op. cit. supra*), but others are additions to his list. Specific identification of the latter would be difficult and doubtful and has not been attempted. In the following list the letters W and T denote Walu Bay and Tamavua respectively :—

Corbis sp. W.T.
Tellina sp. (not *T. suvaensis* Mansfield). T.
Chama ? sp. W.

Cardium sp. W.
Laevicardium sp. = Mansfield, pl. vi, fig. 1. T.
Fragum ? sp. W.
Meiocardia sp. = Mansfield, pl. vi, fig. 3. W.
Antigona ? sp. = Mansfield, pl. vi, fig. 4 or 5. T.
Dosinia ? sp. = Mansfield, pl. vi, fig. 2. T.
Spondylus sp. W.
Plicatula ? sp. W.
Lithophaga sp. = Mansfield, pl. v, fig. 2. W.
Volsella [*Modiola*] sp. T.
Pecten sp. W.
Trochus (*Clanculus* ?) sp. = Mansfield, pl. iii, fig. 4. W.
Turbo ? sp. *a* Mansfield. W.T.
Cypraea sp. W.
Scaphander sp. W.
Globular Lithistid Sponge. T.

The University of Sydney possesses a large internal cast (about 15 cm. high and 20 cm. across) of a *Turbo* from the Walu Bay limestone, identified as *T. marmoratus* Linné. This was very kindly lent to Dr. Matley, and I have been able to compare it with the other *Turbo* cast. Unfortunately the apex is missing, while Dr. Matley's specimen has the apex well preserved but scarcely attains the diameter at which the Sydney specimen commences. All the indications, however, point to the Sydney specimen being more depressed apically than either *Turbo* sp. *a* or sp. *b* as figured by Mansfield. It is probably therefore a third species, and it agrees in general form with *T. marmoratus*, though the final whorl does not show the faint indication of a carina that one would expect in an internal cast of that species.

The most conspicuous foraminifer is a large species of *Cycloclypeus*, attaining about 4 cm. in diameter: so far as could be determined, these large forms are microspheric; their large size and fragility made their full determination difficult. There are also present in great abundance small megalospheric forms of the same genus, 2 to 2·5 mm. in diameter: many of these are naturally split along the equatorial plane so that the megalospheric character can easily be seen. It is natural to assume that these are dimorphic forms of the same species, but while the microspheric forms resemble the recent *C. carpenteri*, the structure of the nucleoconch in the small forms is nearer to that of *C. annulatus*. Further investigation will be necessary to determine the species.

The other foraminifera are the two ubiquitous forms *Amphistegina* sp. (*lessonii* ? d'Orb.) and *Operculina complanata* Defr., and a small discoidal *Gypsina*, probably *G. howchini* Chapman. The list will therefore stand:—

Cycloclypeus sp. cf. *carpenteri* Brady (microspheric).
Cycloclypeus sp. cf. *annulatus* Martin (megalospheric).

Gypsina sp. cf. *howchini* Chapman.
Operculina complanata Defrance.
Amphistegina sp. (? *lessonii* d'Orbigny).

The presence of *Cycloclypeus* without either *Lepidocyclina* or *Miogypsina* suggests a comparatively late date which cannot be fixed more precisely until the species of the first-named genus is determined accurately. The suggestion of a late Miocene or early Pliocene date is, however, confirmed by the record of large teeth of *Carcharodon megalodon* in the Walu Bay limestone.

(*b*) *Fossils from the Kalabu limestone.*

Only foraminifera were collected here. They include very large species of *Lepidocyclina* in abundance, the structure of which is sometimes beautifully weathered out. Owing to the large size and fragility of these forms it has not yet been possible to get good equatorial sections, and the initial chambers have not been made out. The general form of the equatorial chamberlets and the structure of the lateral layers enable, however, very probable identifications to be made, as stated below.

There are also many specimens of a small *Cycloclypeus*, smaller than that of Walu Bay (1·7 mm. diameter), the general structure of which agrees with that of *C. martini* Van der Vlerk, which, however, is a larger species (4 mm. diameter).

The above were the only forms satisfactorily isolated, but two other genera were recognized in rock-sections, as well as a larger *Cycloclypeus*, probably the microspheric form of the species already mentioned. The full list is as follows:—

Lepidocyclina sp., probably *L.* (*Eulepidina*) *insulae-natalis* Jones and Chapman.
Lepidocyclina sp., probably *L.* (*Amphilepidina*) *gigantea* Martin.
Cycloclypeus sp. cf. *martini* Van der Vlerk.
Amphistegina sp.
Linderina sp.

The association of *Eulepidina*, *Amphilepidina* and *Cycloclypeus* dates this limestone, according to Douvillé's time-scale,[1] as Middle Aquitanian, and this agrees with Nuttall's reference of the Upper Orbitoidal Limestones of Christmas Island with *L.* (*Eul.*) *insulae-natalis*. Even if we hesitate to date the Kalabu limestone so precisely, it is clear that it must belong to a much lower horizon than that of Walu Bay, and must come low down in the Miocene.

(*c*) *Molluscan Casts from a High-level Sandstone near Nasoqo.*

The most abundant of these casts are small, ovate, compressed bivalve shells, preserved as internal casts of single valves, the shell-substance being represented, if at all, by a thin film of limonite. No satisfactory external impressions were obtained.

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[1] H. Douvillé, "Révision des Lepidocyclines": *Mem. Soc. Géol. France*, N.S., Mém. No. 2 (1924–5), p. 84.

The most conspicuous feature in the internal casts is the presence of impressions of long lamellar teeth, lying both in front of and behind the umbo, to which they approach so closely that they cannot be described as anterior and posterior lateral teeth, but must be regarded as elongated cardinals. Such teeth can only be matched in the Naiadacea.

Several objections to the reference of these shells to the freshwater mussels at once arise. (1) They are too nearly equilateral, the beak being from $\frac{2}{5}$ to $\frac{1}{2}$ the length from the anterior end. The first of these proportions is not, however, unknown among Unionidae, e.g. in *Parreysia corrugata* (Müller) from India. (2) They show no trace of ornament other than concentric growth-lines. This degeneration of ornament is, however, found in most groups of Unionidae, sometimes extending even to the disappearance of beak-sculpture; besides, only very well-marked ornament would be preserved in sandstone casts, especially internal casts. (3) The marks of the muscle-scars and pallial line are extremely faint. This is, however, a general feature of very thin-shelled freshwater mussels, the deepest scars being always associated with great thickness of shell. There are recent species of *Nodularia* and *Dalliella* in which these marks are as faint as in the fossils.

If, then, these are freshwater mussels, to what group can they be referred? The friability of the sandstone rendering the taking of wax or other impressions too risky a procedure, I had recourse to the method of comparing the fossils with gutta-percha internal casts of recent shells. I have to thank Dr. M. R. Sahni for the skilful preparation of these impressions. The recent forms chosen for comparison were the Australian species *Diplodon australis* and *D. zelebori* and the Oriental *Parreysia corrugata*, *Lamellidens marginalis* and *Nodularia pachysoma*. Only the last of these showed any close resemblance to the fossils, and I am inclined to believe that a cast of *Nodularia olivaria*, of which I was unable to obtain a specimen, would be closer still. In the group of which this last species is the type, the beak-sculpture is obsolete. I propose, therefore, to refer these fossils provisionally to the Indian group of *Nodularia olivaria*, which should perhaps be placed in Prashad's genus *Indonaias*.

The dimensions of these shells are variable. All are small, the largest measuring about 27 mm. in length and 19 mm. in height. On an average of seven the height is $\frac{2}{3}$ the length, and the umbo a little in advance of the centre (45 per cent of the length from the anterior end), but they seem to fall into two series, in one of which the height is about 0·6 and the umbonal distance 0·4 of the length, while in the other these proportions are about 0·7 and 0·5 respectively. Whether this difference indicates the presence of two species is not worth discussing. Since it is advisable that these fossils should have a name, I prefer to take the best-preserved as the holotype of a new species and to treat the others as paratypes.

NODULARIA VITIENSIS sp. nov.

Oval, rather compressed, height about $\frac{2}{3}$ the length; umbo low, placed $\frac{2}{5}$ of the length from the anterior end; siphonal ridge present but obscure; interior marked by growth-lines, but neither beak-sculpture nor muscle-scars clearly recognizable. Hinge-teeth: in the right valve, a short, slightly curved dental lamella extending from the umbo obliquely forwards and downwards, and a long straight lamella extending back, the angle of divergence of the lamellae being about 145°; [in the left valve, two short anterior lamellae placed *en échelon* and diverging at an acute angle, and one long posterior lamella].

Holotype: B.M. L 44211. Internal cast of right valve: length 14 mm., height 9·5 mm., anterior lamella 3 mm., posterior lamella 7 mm.

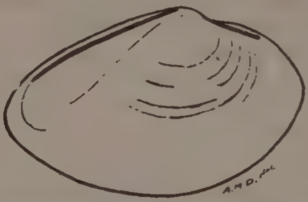

FIG. 3.—*Nodularia vitiensis* sp. nov. Holotype, B.M. L 44211: internal cast of right valve. × $\frac{8}{3}$. The thick black lines are the impressions of the dental lamellae. A faint, incomplete outline of the posterior adductor-scar is seen on the left of the figure.

Paratype on which the diagnosis of left-valve characters is based: B.M. L 44212. Internal cast of left valve: length 18 mm., height 12·5 mm.

Other casts occur along with *Nodularia vitiensis*, though none are so satisfactory. There are three examples of a small, rather inflated, trigonal shell, about 7 mm. long, having a well-marked oblique ridge delimiting the siphonal area; some fragments of a small holostome gastropod, possibly a *Vivipara*, all casts. There are also several fragmentary impressions of dicotyledonous leaves with prominent veins. Nothing in these associated fossils is inconsistent with the freshwater character of the sandstone.

The consequences which follow from the acceptance of *Nodularia vitiensis* as a freshwater fossil are so important that I could wish the evidence were more unquestionable, and must hope that further collecting will remove any doubt. For, at the present time, according to C. T. Simpson,[1] freshwater mussels are not found in

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[1] "Synopsis of the Naiades or Pearly Fresh-water Mussels," *Proc U.S. Nat. Mus.*, vol. xxii (1900), p. 506.

Fiji: the nearest lands in which they live are the Solomon Islands and New Zealand. Their present distribution pays no attention to Wallace's Line: the Solomon Islands species being congeneric with one of Borneo, while the Australian forms have no relation to those of New Guinea. If my interpretation of these casts be correct, they are related to Oriental, not to Australian, forms and at the period when the high-level sandstone was being deposited, Fiji, like the Solomon Islands to-day, belonged, in respect of its molluscan fauna, to the Oriental region.

IV. CONCLUSION (C. A. M. and A. M. D.).

The foregoing account may be summarized as under:—

1. Foraminifera, belonging chiefly to the genera *Cycloclypeus*, *Gypsina*, *Operculina*, and *Amphistegina*, occur in the limestone of Walu Bay. The species have not been completely diagnosed, but they are not likely to be older than late Miocene and may be Pliocene.

2. A foraminiferal limestone, resting partly on soapstones and partly transgressing on to basalt or andesite, occurs at Kalabu, a few miles from Suva. The assemblage of foraminifera, chiefly *Lepidocyclina* and *Cycloclypeus*, is older than that of the Walu Bay limestone and probably of Lower Miocene age.

3. The soapstones of Suva, although not deep-water deposits, contain an echinoid congeneric with a form found in the "abyssal" Radiolarian Marls of Barbados. *Globigerina* has been found in the soapstones at a height of some 1,300 feet above sea-level.

4. A sandstone containing leaves of dicotyledonous plants and mollusca has been found near Nasoqo at some 1,100 feet above sea-level. The molluscs have been provisionally determined as freshwater forms belonging to the Unionidae and related more closely to Oriental than to Australian species. The age of the deposit is not known, but it is almost certainly Tertiary and may be Miocene.

5. A petrological description of some rocks from the Basal Complex (a fine arkose, a schalstein, an altered mudstone or tuff, and an epidosite) indicates that they belong to an ancient series and that they have suffered severely from earth-stresses.

In conclusion we wish to express our thanks to Dr. H. H. Thomas for his examination of the rocks and for allowing us to incorporate the results in this paper.

Observations on the genus *Promicroceras*.

By Daisy M. Williams, M.Sc., University College, Swansea.

THE genus *Promicroceras* was separated from *Xipheroceras* by Dr. L. F. Spath to include *Ammonites capricornoides* and the *Am. planicosta* group. The researches of Dr. W. D. Lang on the Dorset coast have shown that the genus *Promicroceras* persists with relatively slight changes from the " birchi " zone up to the " ziphus " zone.[1]

The separation of the species of *Promicroceras* is based mainly on the stages attained in the flattening on the costae on the periphery of the whorl, together with whorl shape and the spacing of the costae. The earliest forms are those which have the costae continuous across the periphery with almost no flattening, e.g. *Promicroceras capricornoides* Quenstedt and *P. pyritosum* Spath. *P. marstonense* Spath is the common form of the Marston Stone and it differs from *P. planicosta* Sowerby in the more rapid growth and greater width of outer whorl. *P. perplanicosta* Spath shows a further flattening of the ribs on the venter than is seen in *P. planicosta.*

In the present investigation, specimens of *Promicroceras* have been examined fron Lyme Regis, from the " Marston Stone " of Marston Magna, and from Radstock. My thanks are due to Dr. W. D. Lang and Mr. S. S. Buckman for kindly lending me specimens from the Lyme Regis and Marston Magna areas, and to Dr. A. E. Trueman for much help and encouragement in the work.

Sutures.—In general, the sutures of members of this genus are never very complex. The wide external saddle [2] is rather flat topped with the first lateral saddle somewhat lower than the ES; the first lateral lobe is usually small and shallow and the auxiliaries few. The ES is cut by two notches and is therefore normally tripartite; but one notch is usually a little deeper than the other, and the divisions of the saddle are unequal. The IL is frequently bifid, but there is a tendency for one of the minor lobules to develop further and therefore produce a feebly trifid appearance. There are slight differences in suture pattern within the genus but the differences are not usually sufficiently prominent or constant to form a means of distinction between the various species, especially as there is some variation in suture line among members of the same species.

Sutural development.—In *Promicroceras planicosta* the first suture has the typical angustisellate pattern; in the second suture there is a shallow external lobe which is deepened in the succeeding sutures. In the seventh suture the EL is divided by a small median saddle. The ES remains entire until a diameter of about 4 mm. is

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[1] W. D. Lang and L. F. Spath, " The Black Marl of Black Ven and Stonebarrow " : Q.J.G.S., lxxxii, 1926, p. 144.

[2] The external saddle, external lobe, first lateral saddle, first lateral lobe, are referred to as ES, EL IS, and IL respectively throughout this paper.

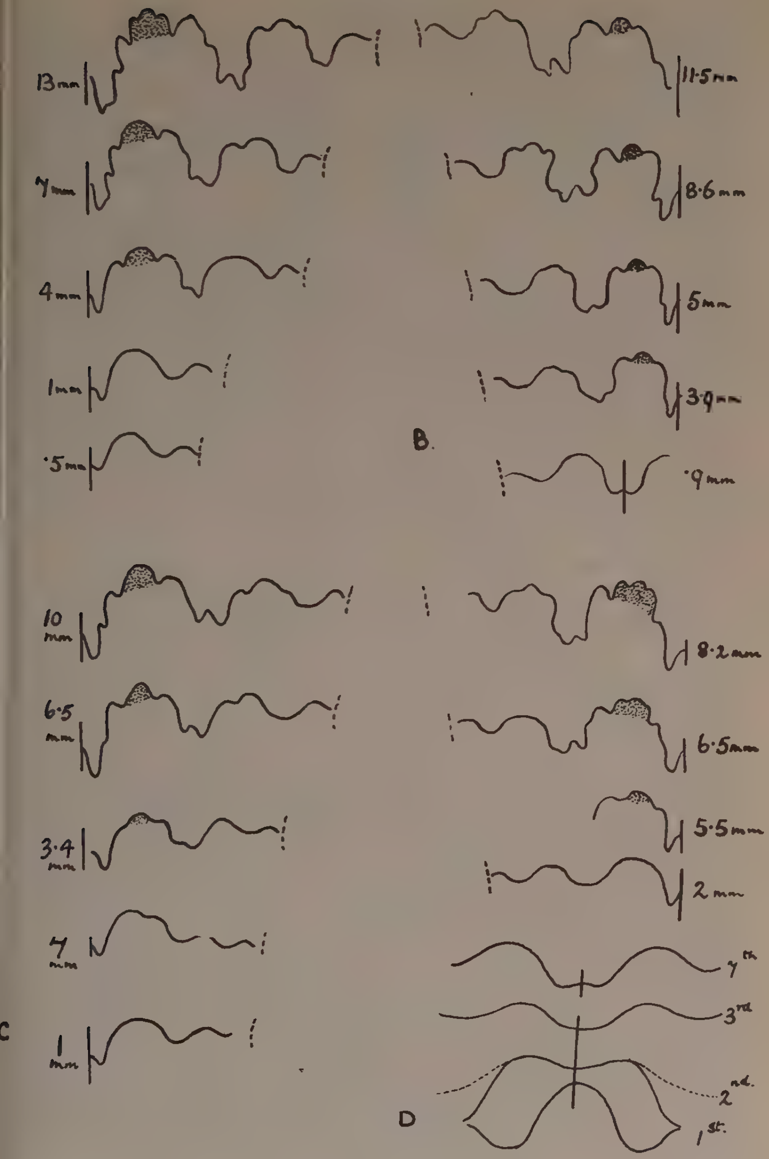

FIG. 1.—Diagrams to illustrate the sutural development of A. *Promicroceras* cf. *pyritosum*, B. *P. capricornoides*, C. *P. marstonense*, D. *P. planicosta*. The median cell of the ES is shown dotted in each case.

reached, when a feeble notch appears on the internal side, and at a diameter of 5 mm. the ES is tripartite. At a diameter of 6·2 mm. the median cell of the ES has become complicated by minor frilling. Meanwhile the three cells of the ES develop unequally and the saddle has become almost bipartite owing to the relatively rapid development of the internal cell of the ES. [The median cell is shown dotted in each of the figures illustrating the sutural development.] The IL remains entire until a diameter of 5·1 mm. is reached, when it becomes feebly bifid. An additional feeble notch on the internal side causes the IL to appear transitional between the bifid and trifid condition ; it is more than half as deep as the EL (Fig. 1 D).

In a dissected specimen of *P. marstonense* a flattening on the umbilical side of the ES is to be seen at an earlier diameter (2·7 mm.) than in *P. planicosta* and this develops into a feebly bipartite ES. At 3·6 mm. the ES is feebly tripartite and develops into an unequally tripartite ES in the adult. It is to be noticed therefore that the tripartite condition of the ES appears to be established earlier in this species than in *P. planicosta.* In some specimens the internal notch of the ES is the deeper one, while in other specimens the external notch is the deeper. The IL is shallow and bifid and about half as deep as the EL (Fig. 1 C).

In a specimen referred to *P.* cf. *pyritosum* a tripartite ES is well defined at 4 mm. and is even more strongly tripartite than in *P. marstonense* at this diameter. The external cell remains small and the internal, and in particular the median cell, become much enlarged. In *P. capricornoides* the ES also passes through a tripartite stage, feebly indicated at a diameter of 3·9 mm., but well established by 5 mm. diameter. The three cells grow to about the same size, but the internal notch is deepened and the resulting ES is unequally bipartite ; what appears to be the external cell of the bipartite ES in this case is made up of the external and median cells of the tripartite stage. The IL of *P. capricornoides* is mainly bifid but shows a tendency to become trifid in the earlier and later stages. It is more than half as deep as EL.

It is to be seen, therefore, that the early development of the suture in various species of *Promicroceras* follows what may be considered a normal course for an unspecialized ammonite.

Each species at some stage or other possesses a tripartite ES. In many cases, however, the tripartite ES develops into a bipartite ES, this being accomplished in at least two ways, namely (*a*) the median and internal cells of the ES develop more rapidly than the external cell of the ES, e.g. the specimen of *P. planicosta* described above ; (*b*) the median and external cells of the ES remain nearly equal while the internal cell of the ES becomes much enlarged and the internal notch is deepened, e.g. *P. capricornoides.*

This can be compared with what has occurred in some species of *Echioceras* in which genus a bipartite ES is considered typical. These species possess a tripartite ES at some stage in their development; for example in a specimen of *E. modicum*[1] a tripartite ES is to be seen in the adult suture (41 mm.) but in a specimen of *E. raricostatoides*[2] the tripartite ES passes into a bipartite ES by the more rapid development of the internal and median cells of the ES. In the case of *E. aeneum*[3] however, the adult suture shows a bipartite ES which seemingly had developed from an ES which was never tripartite.

Whorl shape.—The changes in whorl shape have been studied by means of transverse sections of the shell taken through the protoconch (Fig. 2). It will be noted that the embryonic and nepionic whorls of *P. capricornoides* and *P.* cf. *pyritosum* are crescent shaped, embracing the preceding whorls to a great degree, and as a result of this the umbilicus at the centre becomes deep and narrow. The early whorls of *P. planicosta* and *P. marstonense* on the other hand are more evolute; the ratio of whorl height to the depth of the impressed area is about 5 : 1 compared with about 2 : 1 in *P. capricornoides* and *P. pyritosum.* The central portion of the umbilicus in *P. planicosta* is therefore shallow and flattened. In other words the increase in umbilical diameter for the same number of whorls in the early stages of *P. capricornoides* and *P. planicosta* is less in the former than in the latter. It is evident then that there is some difficulty in estimating the actual diameter from the umbilical diameter. Taking only umbilical diameter into consideration there seems to be some variation in the diameter at which ribbing appears; sections, however, show that the actual diameters in these cases are about the same, and in any case the ribbing appears after about the same number of whorls. For example, the average

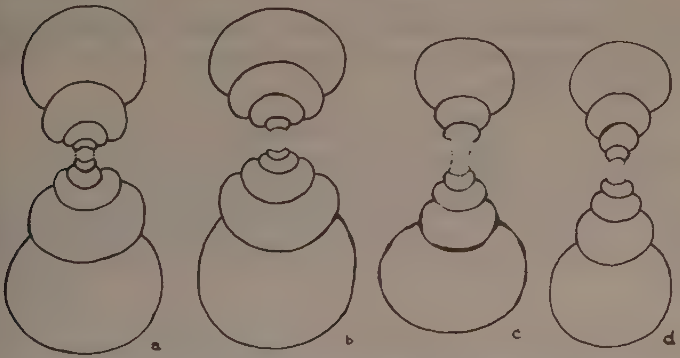

FIG. 2.—Transverse sections taken through the protoconch of (*a*) *Promicroceras capricornoides*, (*b*) *P. pyritosum*, (*c*) *P. marstonense*, (*d*) *P. planicosta*. × 9.

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[1] "Studies in the Ammonites of the Family Echioceratidae," A. E. Trueman and D. M. Williams, *Trans. Roy. Soc. Edinb.*, vol. liii, 1925, p. 714, fig. 8.

[2] Ibid., p. 708, fig. 5.

[3] Ibid., p. 716, fig. 12.

umbilical diameter at which the first rib appears in *P. capricornoides* and *P. pyritosum* is between 4 mm. and 4·5 mm. The number of specimens of *P. planicosta* and *P. marstonense* available for measurement was considerably smaller, but the umbilical diameter at which ornamentation appeared ranged from 5·2 mm. to over 6 mm. This at first sight appears to suggest a lengthening of the early smooth stage in the development of the planicosta group, which is presumed to have evolved from a capricornoides-like ancestor. But the evidence from the transverse sections shows that the number of whorls in *P. planicosta* at the umbilical diameter of 5 mm. is about the same as the number in *P. capricornoides* at the umbilical diameter of about 4 mm., and it may be suggested that the smooth stage in each species of *Promicroceras* extends over approximately the same number of whorls.[1]

Some Unmapped Faults in the Lower Carboniferous of Westmorland and their Relation to the Dent Fault System.

By A. A. Miller, M.Sc.

THE detailed mapping of the area lying immediately to the east of the Dent Fault in the neighbourhood of Kirkby Stephen has revealed the presence of certain faults which had previously escaped notice. These faults have a direct bearing on the Dent Fault system, and are intimately connected with the boundaries of the " Rigid Block ".

In the mapping of these faults the faunal horizons established by Professor Garwood in 1912 have been of great value, especially the Girvanella Bed which marks the division between D_1 and D_2, and the Bryozoa Band between S_2 and D_1. Other horizons of less widespread development have been used locally ; among these an extremely useful band is a layer of limestone about 18 inches thick, crowded with reefs of *Lithostrotion irregulare.* Just above this there occurs a dark shale about a foot thick, which is extremely rich in several species of bryozoa, and this is followed by another reef of *Lithostrotion irregulare* of about the same thickness as the one below. It is well seen in Kitchen Gill at a point just east of Ridding House. It closely resembles the Bryozoa Band at the base of D_1, but is followed by a full development of *Cyrtina carbonaria* and *Nematophyllum minus* beds. Its horizon, therefore, appears to be low in S_1.

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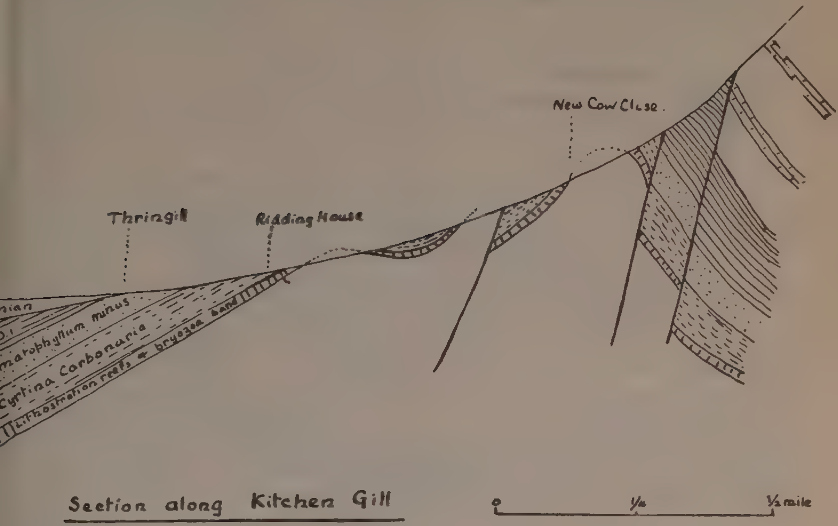
[1] In comparing the developments of different ammonite species it is usual to record the stages attained at known diameters, but it appears possible that in certain cases such records may be misleading or less useful than records of the number of the whorls at which given characters are attained. Thus in capricorn members of the Liparoceratidae ornamentation appears at a much smaller diameter than in their bituberculate descendants, but since the whorls are more swollen in these, it is probable that there is little difference in the actual number of unornamented whorls.

The dominant tectonic feature of the area is the Dent Fault which extends in a general N.N.E and S.S.W. direction from Kirkby Stephen, where it passes under the Permian and Trias, to Kirkby Lonsdale, where it is merged into a complicated fault system at its junction with the Craven Faults. The hade is almost vertical at the south end, but north of Dentdale it is a reversed fault hading to the west. The beds on the east side, with which we are now concerned, show that it traverses higher and higher zones southwards to about Hebblethwaite, a wedge of lower beds comes in in the River Clough, but south of this point D_1 and D_2 border it on the east nearly to Kirkby Lonsdale. These can be tabulated thus :—



Section along Kitchen Gill

FIG. 1.

S_1	. .	East of Kirkby Stephen.
S_2	. .	East of Ash Fell and Ravenstonedale.
D_1	. .	At Fell End Clouds.
D_2	. .	At Whinney Gill.
D_2	. .	At Hebblethwaite.
D_1	. .	In Dovecote Gill.
? S_1	. .	In the River Clough.
D_1	. .	At Brown Moor and Gawthrop.
D_2	. .	In Barbondale.
D_2	. .	East of Kirkby Lonsdale.

Southwards it appears to die away and become confused with the Craven Fault System. It has a displacement of about 600 feet at Hole Beck Gill, bringing the basal conglomerate against the higher beds of the Great Scar Limestone. The wedge of lower beds in the River Clough means that the throw is much less here, but it rapidly increases again to the north. About Whinney Gill and the River Rawthey it splits into two or more branches and an East and a West Dent Fault can be recognized. Here there are huge masses of rubbly limestone material having all the appearance of a fault breccia. The western branch is the more important, and continues on almost parallel to the Sedbergh—Kirkby Stephen road.

East of Ash Fell Edge it appears to have little or no effect, except a slight change of strike of the S_2 beds, which here occur on either side of the fault. The line of disturbance, however, seems to have been shifted about a mile to the east, because the series of hills known as Birkett Knott, Great Bell, High Out Wood, Birkett Hill, and Hartley Birkett, which all consist of D_1 limestone, are bordered on the east by an intense monoclinal fold becoming more and more severe to the north, until it is replaced by a reversed fault at Birkett Hill and Ladthwaite Bottom. This causes the top of D_1 with the Girvanella Bed to occur twice, dipping at 80 degrees to the west on the east side and at a similar amount to the east on the west side. It appears to be the rigidity of D_1 which has determined the position of the fold, the lowest beds of D_2 being largely composed of less resistant sandstone and shale.

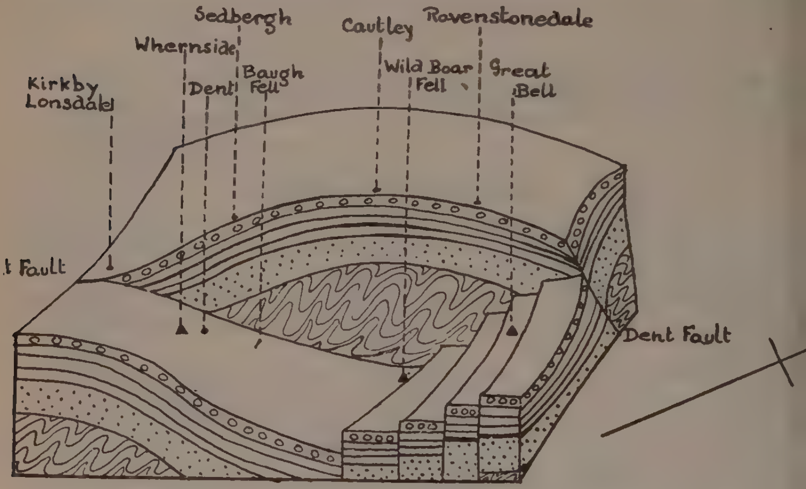


FIG. 2.—Diagrammatic illustration of the Dent Fault and associated cross-faults, prior to denudation.

This line, then, is the true western limit of the " Rigid Block ", against which pressure from the west has crushed the Silurian and Lower Carboniferous rocks, causing them frequently to override the rocks on the eastern side.

This line of folding and faulting is broken by a series of several E.S.E. and W.N.W. faults with downthrow to the south, which have apparently assisted in the foundering of the "Rigid Block". The mechanism of this is shown in the accompanying diagram (Fig. 2). The cross-faults appear to be of approximately the same date as the Dent Fault itself, sometimes displacing the N.N.E. and S.S.W. folds and faults, sometimes being displaced by them.

That the south end of the "Rigid Block" has remained approximately still, and that the north end has subsided about Kirkby Lonsdale as a pivot, is borne out by the slight north-easterly dip of the whole mass, a dip which causes the south sides of those dales such as Dentdale and Garsdale which run east and west to be wet with springs, while the north sides are dry and practically devoid of springs, the water that falls on them being immediately deflected northwards along bedding planes of shale to emerge on the south side of the next dale.

Two supplementary faults occur to the east of Kirkby Stephen, and, like the Dent Fault, their downthrow is to the east. As they bring limestone against limestone they were not noticed by the Survey, but they cause repetition of the faunal zones of S and D. One of these is a continuation of the Catagill and Janny Wood fault, and runs north over the western shoulder of Great Bell, where it brings the *Cyrtina carbonaria* zone against D_1, cutting out the *Nematophyllum minus* beds. From here it crosses Kitchen Gill at a point just east of the exposure of a bryozoa band and reefs of *Lithostrotion irregulare*, a horizon near the base of S, which is valuable for local mapping. The beds here roll about considerably, and are much folded and crushed. Slightly lower beds are exposed further upstream and the bryozoa band and Lithostrotion reefs go up the bank and disappear. But *Cyrtina carbonaria* is found again in some scars in the bank just below New Cow Close and soon afterwards the Lithostrotion reefs appear from below. The fault which causes this repetition I have mapped in at a point opposite a small wood on the north bank of Kitchen Gill where the beds are a good deal disturbed and where there is a great development of calcite.

If continued northwards this fault would cross the Swaledale road near the point where Middleber Sike disappears underground, a feature which may be due to the fault. Beds with *Nematophyllum minus* here dip to the north-west, apparently under beds with *Cyrtina carbonaria*, which, in turn, are followed by more *Nematophyllum minus* beds. The first are obviously faulted into position, the downthrow being to the east. This fault is traceable northwards to Birkett Hill, where it causes a change of direction of the scars and is responsible for some very steep dips.

The other supplementary fault, also with downthrow east and

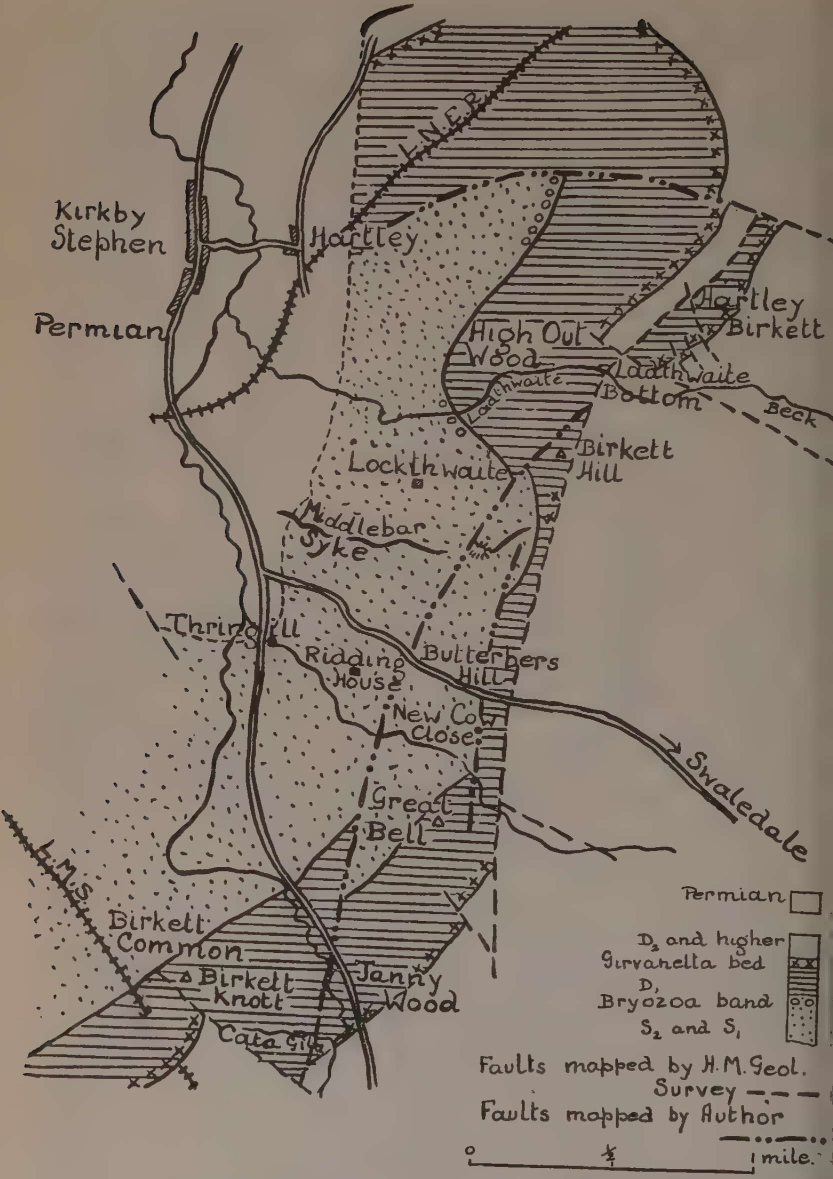


FIG. 3.—Map of the district E. and S.E. of Kirkby Stephen.

parallel to the main fault shown on the Survey map, passes through New Cow Close and Butterbers, bringing *Cyrtina carbonaria* beds against low Yoredale beds in Kitchen Gill. What must be almost the face of this fault is seen in an old quarry with a limekiln at Butterbers Hill, where limestone with *Cyrtina carbonaria* and abundant *Lithostrotion portlocki* dips almost vertically with a north and south strike.

Yet another fault which has not been mapped previously runs from Longrigg to near Hellgill Howe, east of Kirkby Stephen. It is mapped by the Survey as far west as Longrigg, a great scar of D_1 limestone, which it shifts eastwards on the south or upthrow side, but it appears to have a continuation for a mile westwards. This is shown by the fact that it cuts off the Bryozoa Band at the top of S_2, just north of the old quarry north of Birkett Lane, and also by the shifting of certain limestone scars which lie further to the west.

SUMMARY AND CONCLUSIONS.

1. The Dent Fault diminishes in throw towards the north, and is almost non-existent 3 miles south of Kirkby Stephen.
2. The principal line of dislocation is then displaced about a mile to the east, where there is a steep monoclinal fold, replaced sometimes by a fault, running in a direction parallel to the Dent Fault and also having a downthrow to the east.
3. Further parallel faults, many of them hitherto unmapped, assist in the subsidence of the country to the east.
4. Cross-faults, in most cases with downthrow to the south, accommodate the margin of the "Rigid Block" to local increase or decrease of throw.
5. These two systems of faults are of approximately the same age, and were brought about by the same crustal movements.

In conclusion, the author wishes to record his indebtedness to the Royal Society for a grant placed at his disposal and to express his thanks to Professor Garwood and Miss Goodyear for advice and assistance, and also to J. S. Turner, B.Sc., for valuable help in the field.

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REVIEWS.

The Geology of Oil, Oil-Shale, and Coal. By Murray Stuart. pp. 104. London: Mining Publications, Ltd., 1926. Price 7*s.* 6*d.*

THIS publication gives an entirely false impression of the application of geology to the search for oil, oil-shale, and coal. It is the product of a vivid imagination and contains for the most part an elaborate exposition of certain original and highly speculative theories held by the author. He has ignored nearly all the important recent work on the origin of oil and oil-shale published in America.

The accuracy of several of his statements may be challenged: firstly regarding the origin of coal he writes (p. 19): " Coal is a black mud, just as Jukes said some eighty years ago; carbonization of vegetable matter took place in freshwater swamps or lagoons under the action of the carbonizing bacteria, and on such swamps or lagoons being broached or drained off, owing to earth movements that were taking place at the time, the products of carbonization of vegetable matter under bacterial action were carried into estuaries or the open sea by rivers in the form of a black carbonaceous mud, which was laid down as a sediment." On p. 25 he states that strata deposited off a coast may " consist of conglomerate near the shore and pass gradually into sandstone and then into clay or shale which would pass gradually through carbonaceous shale into true coal, when traced away from the direction of the old shore line ". Writing of certain bacteria (p. 34): " It also seems not unlikely that they (the bacteria) might, under certain circumstances, be able to split up the H_2O molecule and take the combined oxygen out of it." In discussing the relation of fossil wood to oil (pp. 74–6) it would be interesting to know what evidence he has for the formation and accumulation of " gelatinous and cheese-like silicified wood " in streams. We are not convinced when on p. 86 he tells us that " the discovery by Dr. H. de Böckh and the geologists of the Anglo-Persian Oil Company of Trilobites in the strata associated with the salt of the Persian Gulf area more or less establishes the early Cambrian or Pre-Cambrian age of the salt of North-West India ". On p. 94 we have brought to light for the first time " the discovery of the fact that Burma has been affected by an important overthrust which has thrust the surface portion of the strata for a considerable distance in a westerly direction over the strata situated below the plane of the overthrust, very seriously complicates the oil geology of the country ". Finally the book contains a good deal of irrelevant matter, for instance, in the chapter on " Limestone Oils " (p. 36) we are astounded to hear " Enclose a mammal in a closed space and as a result of that action the mammal will cease to exist ".

W. L. F. N.

PFLANZEN ALS GESTEINSBILDNER. By J. PIA. pp. viii + 355, with 166 text-figures. Berlin: Gebrüder Bornträger, 1926. Price 19·50 M.

THE important part played by animals, especially the lower invertebrates, in the formation of some sedimentary rocks, is perfectly familiar. Dr. Pia maintains, in this well-illustrated textbook, that plants are of at least equal importance in the building up of massive deposits, while they show more diversity than animals in methods of accumulation. In support of this thesis he gives an ingenious classification of "organic" rocks, that is, rocks formed either by direct organic agency, or by the accumulation of the products or hard parts of organisms, and in the sequel he considers in detail the influence of plants in the formation of these rocks.

There are valuable accounts of sulphur- and iron-bacteria and the deposits to which they give rise, and the section on the Cyanophyceae includes reference to certain petrifications which can "with more or less probability" be attributed to their agency. By a rather too easy transition, Dr. Pia passes from the possibility of such petrifications being formed by blue-green algae, to the acceptance of the algal origin of forms like *Cryptozoon* and *Collenia*. He does not discuss here the possible explanation of these and similar structures as diffusion phenomena of the type associated with the name of Liesegang. He does, however, point out that present-day calcareous Cyanophyceae are freshwater algae, whereas most of the petrifications in question occur in marine strata. In the absence of definite proof of algal origin, Kalkowsky's term "stromatolith" might usefully be employed for many of these curious bodies.

Diatoms are fully dealt with, as well as the Silicoflagellata, which are perhaps more usually regarded as Protozoa, and there is a section on the role of unicellular plants in the formation of coal and petroleum. The calcareous Dasycladaceae and Codiaceae are well treated, as one would naturally expect from the leading authority on the fossil members of these families, but even here one would have welcomed more illustrations of actual fossils. The figures are numerous and clear, but the majority are either of recent forms or of reconstructions of fossils. For the worker in field or laboratory illustrations of fossil calcareous algae, both of external features and appearance in thin rock-sections, would have been more useful than the numerous figures of recent flowering plants given in the last chapters.

Indeed, in the second half of the book, which is almost entirely concerned with coal and peat, and the plants from which they were formed, the author seems to waver between keeping within the limits of his title and producing a general textbook of fossil botany. For example, the rare and local Jurassic plant *Williamsoniella* which receives a page of description and illustration, can scarcely be of any importance as a rock builder, nor does one naturally think of buttercups and forgetmenots in this connexion, even though their remains may be occasional constituents of peat.

There is a great deal of interesting matter in the chapters on the formation, constitution, and occurrence of coal, but this subject has been treated so often, from various standpoints, that it has not, perhaps, the value and importance of the first half of the book, which is the best and fullest, almost the only, general account of algae as rock builders.

W. N. E.

VERSUCH EINER NATÜRLICHEN KLASSIFIKATION DER IM WEITEREN SINNE MAGMATISCHEN ERZLAGERSTÄTTEN. By P. NIGGLI. Abh. d. prakt. Geol. und Bergwirtschaftslehre. Band i, pp. 69, with 11 figures. Wilhelm Knapp, Halle (Saale), 1925.

IN recent discussions in this country of the origin of ore-deposits, there has been a tendency, especially on the part of petrologists and general geologists, to minimise the importance of a direct igneous origin and to attribute a very large share of the work of ore-formation to replacement by solutions of somewhat vague and mysterious origin. This apparent tendency no doubt arises to some degree from different ideas as to what really constitutes a magmatic solution: it is largely a question of definition. But there are certain writers who go beyond this, and explicitly deny that the ores are derived from magmas at all. This small but very interesting book by Professor Niggli, which is to be regarded as the logical continuation of his invaluable work on the volatile constituents of the magma, and on petrographical provinces, is an emphatic restatement of the magmatic theory of the origin of the greater part of the vein-deposits and of many other categories of ore-bodies. The author very strongly emphasizes his contention that the study of ore-genesis is an integral part and necessary continuation of the petrography of the igneous rocks, which is logically incomplete if this phase is omitted, either in general discussions or in detailed descriptions of particular areas.

In his discussion of the subject and in the classification finally drawn up the author takes full account of several large German textbooks; of the great work of de Launay, in France, and of recent American writers (Lindgren, Emmons, and Spurr), but it is somewhat noticeable that no English writer is even referred to. If Professor Niggli had been acquainted with the English literature of ore-deposits of the last three or four years he would have found that a very large proportion of his conclusions have already appeared in print in this country.

After a brief account of the physical chemistry of a cooling magma, Professor Niggli goes on to discuss the differences that characterize the successive stages of the process; while fully recognizing that these grade into one another, he finally comes to the conclusion that three distinct phases of differentiation and crystallization can be recognized. The first liquid-magmatic stage embraces the formation of the true igneous rocks with concentration of volatile constituents in the residues. This leads to the second stage, pegmatitic and pneumatolytic, whose character scarcely needs definition here; its final result is the formation of a watery residue, the hydrothermal stage. Certain high temperature ores belong to stage 2: to mention one example only, the tin-tungsten-molybdenum paragenesis, but the great majority of primary ore-bodies arise in orderly sequence from the hydrothermal stage, the well-known zonary sequence of metals being fully accepted. Further, considerable importance is attached to volcanic phenomena, including submarine eruptions, which have led, for example, to the iron ores of Lake Superior.

Some parts of this book will doubtless be rather a jar to the extreme anti-magmatists in whom the baneful influence of the lateral secretion theory is still traceable, but it is refreshing to find a petrologist so eminent as Professor Niggli really letting himself go on this interesting and important subject.

THE GEOLOGY OF THE COUNTRY AROUND ROMFORD. By H. G. DINES and F. H. EDMUNDS. Mem. Geol. Surv. Explanation of 1 in. Sheet 257, England. pp. xiii + 53, 3 text-figures and 2 plates. 1925. Price 1*s.* 6*d.*

THIS area, which extends eastward to include parts of Epping Forest and the eastern suburbs of London, has been remapped on the 6 in. scale. Beds of Eocene and Pleistocene age make up the bulk of the country; the small outcrop of Chalk is not described. A map showing the underground contours of the surface of the Chalk is a useful feature.

A. G. B.

THE GEOLOGY OF THE COUNTRY NEAR LEWES. By H. J. OSBORNE WHITE. Mem. Geol. Surv. Explanation of 1 in. Sheet 319, England. pp. xii + 97, 11 text-figures and 4 plates. 1926. Price 2*s.* 6*d.*

THE district around Lewes is of interest both as the home of Gideon Mantell and as the scene of the discovery of the Piltdown Skull. The solid deposits range from Purbeck to Upper Chalk. Paucity of exposures prevents the author from doing more than summarize existing accounts of the Purbeck, and from determining accurately the horizons represented in the Albian; happily the Chalk is well exposed. The river gravels have been remapped by Mr. F. H. Edmunds, who has also revised some of the boundaries of the older deposits.

A. G. B.

REPORTS AND PROCEEDINGS.

MINERALOGICAL SOCIETY.

2nd November, 1926.

Dr. L. J. Spencer: Schultenite, a new mineral, from South-West Africa.

The colourless platy crystals from Tsumeb are monoclinic ($a:b:c = 0{\cdot}8643:1:0{\cdot}7181$, $\beta = 84°\ 36'$) and gave on analysis by E. D. Mountain the formula $PbHAsO_4$. They are identical with crystals prepared artificially by the late Baron A. de Schulten in 1904 (see *Nature*, 18th September, 1926, p. 411).

Dr. L. J. Spencer: Aramayoite, a new mineral, from Bolivia.

This was found in 1925 in a silver-tin vein in the Animas mine at Chocaya. It shows a confused aggregate of cleavage plates with iron-black colour and brilliant metallic lustre. In addition to the perfect basal cleavage there are also good cleavages following a steep tetragonal pyramid. The mineral is pseudo-tetragonal. Analyses by T. B. McGhie and by E. D. Mountain give the formula $Ag(Sb,Bi)S_2$.

K. Yardley: X-ray Examination of Aramayoite.

Some photographs taken with beam perpendicular to the perfect basal cleavage (001) show no symmetry; powder photographs also show that the tetragonal symmetry apparently indicated by the cleavages does not actually exist. Ionization spectrometer data reveal the triclinic nature of the mineral and give a complete crystallographic description: $a = 5{\cdot}672$ Å.U., $b = 5{\cdot}688$, $c = 5{\cdot}623$; $\alpha = 86°\ 55'$, $\beta = 90°\ 53'$, $\gamma = 93°\ 18'$. The structure is pseudo-tetragonal with two molecules of $Ag(Sb,Bi)S_2$ in a minimum cell.

K. Yardley: The structure of Baddeleyite and of prepared ZrO_2.

The natural form of ZrO_2 is monoclinic with four molecules in the unit cell. Ionization spectrometer measurements on a single crystal and powder photographs both indicate a distorted CaF_2 arrangement of the ions. The structures of three specimens of the mineral from entirely different sources are practically identical, except for slight variations of spacing due to the presence of impurity. Powder photographs of prepared zirconia from two distinct sources are almost identical with those of baddeleyite and show that prepared zirconia is also monoclinic and not (as previously stated) tetragonal.

W. Binks: The crystalline structure of zircon.

X-ray examination of zircon shows the structure of zircon to correspond to the space group D_{4h}^{19}. The unit cell containing eight molecules $ZrSiO_4$ has dimensions $a = 9{\cdot}30$, $c = 5{\cdot}93$Å. The silicon and zirconium atoms form two interpenetrating face-centred lattices, and the oxygen atoms are arranged tetrahedrally around the silicon atoms. The structure has some resemblances to that of anhydrite ($CaSO_4$).

OBITUARY.

George William Lamplugh, F.R.S., F.G.S., F.R.G.S.

BORN 8TH APRIL, 1859. DIED 9TH OCTOBER, 1926.

The death of George W. Lamplugh removes one of the best known and most popular figures among English geologists. A sketch of his life was published in the GEOLOGICAL MAGAZINE of August, 1918, with a portrait and a list of his published works to that date. He was then President of the Geological Society (1918–20). In his two Anniversary Addresses he dealt in masterly style with two subjects which he had made his own, the Structure of the Weald and the Glaciation of England. In July, 1920, he quitted the Geological Survey, to which he had been attached for twenty-eight years. In his retirement at St. Albans he kept alive his active interest in geological affairs and, until his health broke, continued to take part in the meetings at Burlington House. In 1925 he received the award of the Wollaston Medal as an expression of the high estimate placed upon his services to the science. His latter days were clouded by suffering, bravely endured, and his life closed in October last, in his sixty-eighth year.

So ends a notable career. Lamplugh was eminently one of Nature's geologists, born, not made. Save for a few excursions in the field with Dakyns and others, he was wholly self-taught. The faculty of observation and the capacity for patient labour were innate; the rest came from study in the field, to which he devoted all the time that was his own after his work in a merchant's office at Bridlington. Turning naturally to what lay nearest to hand, he attacked first the problem of the Glacial deposits of Holderness, and then the Cretaceous strata exposed in the cliffs of Flamborough and Speeton. Though in after years the scope of his researches was, of course, much widened, Glacial geology and the stratigraphy and palaeontology of the Cretaceous continued to be his ruling interests. His ardour for the former was quickened by his travels through the United States and Canada in 1884, when he studied the American drift deposits and the great glaciers of Alaska and the Rocky Mountains.

It had long been Lamplugh's ambition to make geology the work of his life, but it was not until 1892 that a chance was presented. Sir Archibald Geikie, ever with a keen eye for the right man, offered him a place on the Geological Survey. The prospect demanded some sacrifice, and indeed, for a married man with young children, some risk, for the pay of an Assistant-Geologist was in those days on a level with that of a dock labourer. Lamplugh, however, took his courage in both hands, and he never afterwards regretted his decision. The Isle of Man, to which he was first assigned, introduced him to a side of geology new to his experience; but he soon found a pleasure in studying the detailed structures of the Manx Slates and deciphering the evidence of successive crust-movements in that complicated area. The memoir in which his results were embodied is indeed a model of what such a monograph should be.

In 1901, with the title of District-Geologist, he was chosen to take charge of the Irish branch of the Survey. Circumstances made this no easy post. Lamplugh's tact and judgment, and a sympathetic insight into human nature, made the best of a difficult situation, but it is safe to say that the years spent in Dublin were not the happiest of his life. From there he was transferred first to the Midlands, and then to the Denbighshire district, until, in 1914, he was made Assistant-Director in London. His new duties were largely administrative, but allowed him still to keep in touch with the field-work which he loved. He found some opportunity also for foreign travel, visiting America (for the third time), South Africa (including the gorge and falls of the Zambesi), Sweden, Spitzbergen, and Australia.

To a man in whom the social instinct was strong, life in London was welcome as bringing him into closer touch with fellow-workers in various lines. He frequented the meetings of the Royal Society, the Geological, and the Royal Geographical, and took a genial part in many less formal gatherings. Lamplugh was always good company. His entire freedom from pretence and pose put him at once on easy terms with all sorts and conditions of men who brought with them a like sincerity. Enthusiastic geologist as he was, he never allowed his chosen profession to fill the whole of his life. He had read widely, and formed his own opinions of books and men. Independence of judgment was controlled by a shrewd common sense, which perhaps owed something to his early business training. A certain underlying quality of broad humanity in the man found expression in a direct style of speech, which did not disdain homely metaphor, and in a native humour, which had occasionally a sub-acid flavour, but always stopped short of the malicious. Only some sham or obliquity could provoke a sterner note.

Upon the value of Lamplugh's services to geology it is not necessary to enlarge, but one characteristic should not pass without notice. Having begun life as an amateur geologist in the country, with little help from outside, he never ceased to take a lively and practical interest in the doings of other amateurs. His frequent visits to provincial societies in Yorkshire and elsewhere have done much to stimulate local research; and to many keen geologists, whose own opportunities are circumscribed, this will seem not the least of his claims to grateful remembrance.

Arthur Walton Rowe, M.S., M.B., M.R.C.S., F.G.S.

BORN 27TH SEPTEMBER, 1858. DIED 17TH SEPTEMBER, 1926.

The death of Dr. Rowe has removed from the ranks of British geologists a highly gifted amateur, whose contributions to the zonal study of the White Chalk are the most important that have been made since the publication of the classic memoir by Barrois in 1876. Rowe's keenness as a naturalist and collector led him at an early age to search for fossils in the districts that lay within easy reach of his home at Margate, and the sections in the Lower London Tertiaries near Herne Bay, the Gault of Folkestone, and the Lower Chalk between East Wear Bay and Shakespeare Cliff were hunting-grounds of equal interest to him. Later, his observations in the White Chalk of the Kent coast convinced him that many criteria for zonal differentiation and diagnosis that had previously been overlooked were to be found in the slow evolutionary changes observable by a critical eye in certain characters of the fossils. He devoted attention in particular to the evolution of the genus *Micraster*.

Rowe's pertinacity and scrupulous care as a collector enabled him to obtain abundant data well suited for his evolutionary studies, and the first-fruits of this work were embodied in his important paper on the genus *Micraster*, published by the Geological Society in 1899. This paper proved of great practical value in geological work, and showed, moreover, what could be achieved by careful collecting in an unbroken series of beds displaying relatively uniform conditions of sedimentation. It provided a stimulus to other investigators to apply the same methods in the study of different groups of fossils.

The work on *Micraster* was followed by comprehensive studies of the zones of the White Chalk as seen in the coastal sections in Kent and Sussex, Dorset, Devon, and Yorkshire, the results of which were published by the Geologists' Association (1900–4). The further paper on the zones of the White Chalk in the Isle of Wight, issued by the same Association in 1908, was framed on rather more elaborate lines, and includes an account of the chief inland sections. During the preparation of these papers, Dr. Rowe worked in conjunction with Mr. C. Davies Sherborn, to whose assistance he owed more than is generally realized. It is perhaps not too much to say that without Mr. Sherborn's encouragement and energetic help, the papers might have remained unpublished. They were written during hours of scanty leisure while Dr. Rowe was busily engaged in his professional duties. The field-work was carried out during spring and late autumn holidays; the examination of specimens and the writing of manuscripts was done chiefly between the hours of 10 p.m. and 1 a.m., after strenuous days of medical and surgical work. When we bear in mind the difficult conditions under which Dr. Rowe carried on his geological investigations, these papers must be regarded as a remarkable achievement. The value of four of them was enhanced by the beautiful photographs made by Professor H. E. Armstrong, in illustration of the chief sections described. The Geological Society recognized the importance of Dr. Rowe's work by the award to him of the Wollaston Fund in 1901, and the Lyell Medal in 1911.

In addition to other adverse circumstances, Dr. Rowe's occupation in hospital work during the War put an end to the publication of further results, although he continued his geological field-work from time to time, particularly in Norfolk. He devoted much time to his great zonal collection of Chalk fossils, which contains abundant proof of his skill in preparing delicate specimens and his care and method in arrangement and labelling. This fine collection, which so fully illustrates Rowe's published papers, has now been acquired by the British Museum (Natural History) and will be available for study. Its special value for stratigraphical work can only be fully retained if the collection is kept intact.

In his own special sphere of geological study Rowe showed a masterly grasp, and to accompany him in his field-excursions was a rare pleasure as well as an education of great value. His keen powers of observation, his method, his enthusiasm, and his command of details significant in zonal work were remarkable. Lack of time was doubtless partly responsible for his somewhat limited outlook on geological problems as a whole. It was not that his mental predilections were narrow, for he showed enthusiastic interest in art, music, literature, horticulture, and antiquarian pursuits.

As a medical man, Dr. Rowe possessed in an exceptional degree those qualities which make for success. He had an unfailing charm of manner, a personal magnetism, and a cheery optimism which endeared him to all whom he attended as physician or surgeon. Apart from his profession, he was apt to show a reticence and preoccupation which sometimes gave rise to misunderstanding. The present writer knew him for nearly thirty years as a staunch and unselfish friend.

F. L. KITCHIN.

CORRESPONDENCE.

THE CHALK AT GUILDFORD.

SIR,—It may be of interest to record the occurrence of Chalk of the *Actinocamax quadratus* zone at Guildford, as this is, I think, the only record of this zone on the North Downs apart from the reference by Barrois (*Recherches sur le Terrain Crétacé supérieur de l'Angleterre et de l'Irlande*, 1876, pp. 139–40) to the detection of *Offaster corculum* (Gold.) [= *Offaster pillula* (Lam.)] on the north of the Hogs Back.

At Guildford Park, about half a mile westward of the railway station, a 10 ft. sewer trench has recently been dug parallel to, and almost at, the junction of the Chalk with the Tertiary beds. This trench exposed Chalk in which both *Marsupites* and *Uintacrinus* were entirely absent, but which yielded *Offaster pillula* (Lam.) and many specimens of *Echinocorys scutatus*, which Mr. A. G. Brighton, who accompanied me on one of my visits to the section, identified as *E. scutatus* var. *depressus* Brydone.

F. H. EDMUNDS.

H.M. GEOLOGICAL SURVEY.

THE OLD RED SANDSTONE OF THE WELSH BORDER.

SIR,—I have read with much interest Mr. Fleet's paper on the petrology of the Old Red Sandstone of the Welsh Border. While the results of the investigation are themselves most suggestive, the interest of workers on sedimentary petrology will naturally centre on the account of the methods employed. Most workers agree that the frequency numbers based on eye estimation or on partial counts are far from ideal, though in the hands of experienced workers they have no doubt been of value. The opinion of these workers on Mr. Fleet's method will be awaited with interest.

My present purpose is simply to state that, at Mr. Fleet's instance, I have given his method a trial with most gratifying results. As noted by him it was applied to the examination of some Diestian sands at Sanderstead, but I have given it a more extended test in the case of certain High Level Pliocene deposits in the centre of the London Basin.

Over a small area the constancy of percentages for deposits of the same group is very striking and it is of definite diagnostic value. Over a wider area a significant regional graduation of the percentages can be detected—a regular increase in the percentage of stable species in the direction of transit of the material pointing to progressive elimination of the less resistant mineral types. The results of the investigation will, it is hoped, be published in due course, but meanwhile I take this opportunity of bearing testimony to the value of the method.

With the progress of work on sediments has come a realization that, striking and obvious differences of mineral content are the exception rather than the rule in British rocks. The mere enumeration of mineral contents is likely to be no more diagnostic of a sediment than it is of an igneous rock, and Professor Boswell has emphasized more than once the necessity of using the varietal characters of mineral species in discussions of provenance and distribution. The determination of the percentages of the more commonly occurring species will be an invaluable supplement to such work. There is still a not unnatural disposition among field geologists to look askance at a method which they cannot themselves employ and which is liable to be marred by a subjective factor. The adoption of the percentage method should do much to reassure them.

S. W. Wooldridge.

King's College, London.
22nd November, 1926.

PLANT PETREFACTIONS IN THE PENNANT ROCK.

Sir,—Following the announcement by Mr. Robert Crookall (Geol. Mag., LXII, Oct. 1925, p. 480) of the occurrence of well-preserved petrified plant remains in the Pennant rock near Bristol and Caerphilly we have to record the presence of similar material in the Pennant rock near Swansea. We have found it in abundance at Cockett quarry, and a few fragments in a quarry on the north side of Town Hill. We have examined a number of specimens both by cutting thin sections and by the new technique mentioned below. So far the structural material investigated is wood of the dadoxylon type, frequently with a layer of coal, apparently representing the cortex. We wish also to report that we have extended the metallographic method of etching a polished surface which has proved so successful with coal (Seyler, *Fuel in Science and Practice*, iv, 56, Feb., 1925) to mineralized plant petrefactions. The results are particularly good with calcareous material such as " coal-balls ", but we have also modified the method for the specimens discovered by us at Cockett quarry, in which the petrifying material is largely ferruginous. We hope to publish details of the method and results shortly.

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